Utah Department of Environmental Quality
Division of Solid and Hazardous Waste

Human Health Risk Assessment

Review Draft

April 2002

Deseret Chemical Depot
Tooele Chemical Agent Disposal Facility (TOCDF)
EPA I.D. No. UT 5210090002

Permitting Authority:

State of Utah Department of Environmental Quality
Division of Solid and Hazardous Waste
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DSHW Work Order No. 001
DSHW Cost Code 6921, 66967 06R
Tetra Tech Project No. 1029001

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APPENDICES

NOTE: All appendices are available from the Division of Solid and Hazardous Waste (DSHW). Appendices B through S are also available in Portable Document Format (PDF) at the DSHW web site http://www.deq.state.ut.us/EQSHW/CDS/CDS_PVA.

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ACRONYMS AND ABBREVIATIONS

ACWA	Assembled Chemicals Weapons Assessment
ADME	Absorption, distribution, metabolism, and excretion
atm	Atmosphere
ATSDR	Agency for Toxic Substances and Disease Registry
B(a)P	Benzo(a)pyrene
BCF	Bioconcentration factor
BRA	Brine reduction area
BW	Body weight
CAMDS	Chemical Agent Munitions Disposal System
CDC	Centers for Disease Control and Prevention
CHB	Container handling building
cm	Centimeter
cm^2	Square centimeter
COPC	Compound of potential concern
CSF	Cancer slope factor
DCD	Deseret Chemical Depot
DFS	Deactivation furnace system
DMP	Dimethylphthalate
DNOP	Di-n-octylphthalate
DSHW	Division of Solid and Hazardous Waste
DW	Dry weight
EMS	Ethyl methanesulfonate
FIR	Food ingestion rate
FW	Fresh weight
g	Gram
GB	Isopropyl methylphosphonofluoridate
H	Bis(2-chloroethyl)sulfide
HD	Distilled H
HHRA	Human health risk assessment
HSDB	Hazardous Substance Databank
HI	Hazard index
HQ	Hazard quotient
HT	A mixture of HD and T
HVAC	Heating, ventilation, and air conditioning
IRAP-*h* View	Industrial Risk Assessment Program-Health®
JACADS	Johnson Atoll Chemical Agent Disposal System
K	Kelvin
K_d	Soil-water partitioning coefficient
kg	Kilogram
km	Kilometer
K_{oc}	Soil adsorption coefficient
K_{ow}	Octanol-water partitioning coefficient
L	Liter
LIC	Liquid incinerator
m	Meter
m^3	Cubic meter
MDB	Munitions demilitarization building
MEI	Maximum exposed individual
MF	Metabolism factor

mg	Milligram
mg/kg	Milligram per kilogram
mL	Milliliter
mm Hg	Millimeters of mercury
MPF	Metal parts furnace
MS	Microsoft
MW	Molecular weight
NA	Not applicable
NCDC	National Climatic Data Center
NE	Not evaluated
PAH	Polycyclic aromatic hydrocarbon
PAS	Pollution abatement system
PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzo(p)dioxin
PCDF	Polychlorinated dibenzofuran
pg	Picogram
pg/kg BW-d	Picogram per kilogram body weight per day
PIC	Product of incomplete combustion
PUB	Process utilities building
RCF	Root concentration factor
RCRA	Resource Conservation and Recovery Act
RfD	Reference dose
s	Second
SAB	Science Advisory Board
SVOC	Semivolatile organic compound
T	Bis-2-(chloroethylthioethyl)ether
TEF	Toxicity equivalence factor
TEQ	Toxicity equivalents
Tetra Tech	Tetra Tech EM Inc.
TIC	Tentatively identified compound
TOCDF	Tooele Chemical Agent Disposal Facility
TOE	Total organic emissions
UDEQ	Utah Department of Environmental Quality
µg	Microgram
$\mu g/m^3$	Microgram per cubic meter
USDA	U.S. Department of Agriculture
U.S. EPA	U.S. Environmental Protection Agency
VOC	Volatile organic compound
VX	O-ethyl-S-[2-diisopropylaminoethyl]methylphosphonothiolate
WHO	World Health Organization
yr	Year

1.0 INTRODUCTION

Tetra Tech EM Inc. (Tetra Tech), under Contract No. 006244 with the Utah Department of Environmental Quality (UDEQ) Division of Solid and Hazardous Waste (DSHW), was issued Work Order 001 to evaluate the potential for adverse health effects that would result from exposure to emissions from treatment of chemical munitions at the Tooele Chemical Agent Disposal Facility (TOCDF) and the Chemical Agent Munitions Disposal System (CAMDS), which are located at Deseret Chemical Depot (DCD) in Tooele County, Utah. The chemical munitions include two nerve agents and sulfur mustard. The nerve agents are isopropyl methylphosphonofluoridate (GB) and O-ethyl-S-[2-diisopropylaminoethyl] methylphosphonothiolate (VX). Sulfur mustard is composed of bis(2-chloroethyl)sulfide (H), HD (distilled H), and HT [a mixture of HD and bis-2-(chloroethylthioethyl)ether (T)].

Task 05 of the work order authorized Tetra Tech to carry out the human health risk assessment (HHRA). The specific technical methods, assumptions, and parameters used in the HHRA are presented in the "Final Human Health Risk Assessment Protocol" for DCD (Tetra Tech 2001b). The protocol (1) describes each of the HHRA exposure scenarios evaluated, (2) describes how emission rates for compounds of potential concern (COPC) were determined for each source evaluated, and (3) presents emission rate values for each COPC. COPCs include both detected and non-detected compounds. Deviations from the protocol also are discussed in this report.

The objectives of the risk assessment are to calculate the cumulative risks and hazards for each exposure scenario specific to each source at TOCDF and CAMDS and specific to each agent campaign. Potential adverse health effects were evaluated (1) separately for each source and each agent, and (2) cumulatively to provide a basis for evaluating the protectiveness of the operating conditions in the Resource Conservation and Recovery Act (RCRA) hazardous waste permits for TOCDF and CAMDS. DSHW has the authority and responsibility to establish permit conditions that are protective of human health and the environment (Utah Administrative Code R315-3-23; Title 40 Code of Federal Regulations 270.32(b)(2)).

The HHRA was completed in accordance with the peer review draft of the U.S. Environmental Protection Agency's (U.S. EPA) *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (U.S. EPA 1998), and the errata issued on August 2, 1999 (U.S. EPA 1999). U.S. EPA (1998) was prepared as national guidance to consolidate information presented in other risk assessment guidance and methodology documents previously released by U.S. EPA and state regulatory agencies. U.S. EPA (1998) has been peer reviewed; however, revised guidance has not been issued as of the date of this HHRA. The latest approved guidance for assessing health risk from RCRA hazardous waste combustors is *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes* (U.S. EPA 1994). However, U.S. EPA no longer supports the air dispersion model recommended in the 1994 guidance. Therefore, the U.S. EPA Office of Solid Waste recommends the use of U.S. EPA (1998) for conducting human health risk assessments on emissions from RCRA hazardous waste combustion units. Risk calculations were performed with the Industrial Risk Assessment-Health® (IRAP-*h* View) software (Lakes Environmental Software 1998), which calculates risk in accordance with the U.S. EPA (1998) guidance.

Risk characterization output from IRAP-*h* View was imported into a Microsoft Access database, which was queried to identify risk and hazard values to meet the objectives of the risk assessment. The database is presented in electronic format in Appendix A. Appendices B through E present revised emission rates for TOCDF and CAMDS. Appendices F through S present electronic IRAP-*h* View output files and Microsoft Access reports in *.pdf format. Adobe Acrobat Reader can be used to open the IRAP-*h* View output files and Access reports. The IRAP-*h* View project files are presented in Appendices T through W.

2.0 SUMMARY OF EMISSIONS FROM TOCDF AND CAMDS

Section 2.0 summarizes information on the sources of air emissions and the methods used to calculate emission rates for COPCs for each source. Detailed information about emission sources, COPCs in emissions, and methods for calculating emission rates for COPCs is presented in the protocol.

The HHRA evaluated six emission sources at TOCDF and four sources at CAMDS. The six sources evaluated at TOCDF include the liquid incinerator (LIC) 1; LIC 2; the metal parts furnace (MPF); the DFS; the brine reduction area (BRA); and the heating, ventilation, and air conditioning (HVAC) system. The four sources evaluated at CAMDS include the MPF, the DFS, the LIC, and the HVAC system. The LIF and MPF at CAMDS share a common stack but do not operate simultaneously. Risks and hazards were calculated for emissions from the MPF only because the data available for comparing emissions from the LIC and MPF suggest that risks and hazards associated with emissions from the MPF will be higher than those associated with emissions from the LIC.

Period of operation may be an important factor because it is used to estimate various terms for characterizing exposure, such as the concentration of COPCs in soil that result from deposition and the concentrations in air used to evaluate the potential for adverse effects from inhalation. As discussed in the protocol, the risk assessment assumed that the agent campaigns at TOCDF would last for a total of 13 years (from 1996 to 2009). For TOCDF, current information indicates that the GB campaign will consume 59 percent (7.67 years) of the total time of operation, the VX campaign will require 19 percent (2.47 years) of the total time, and the sulfur mustard campaign will use 22 percent (2.86 years) of the total time. To evaluate risk associated with treatment of munitions at CAMDS, DSHW estimated a total operating period of 10 years based on available information.

Section 2.1 describes the emission sources at TOCDF. Section 2.2 describes the emission sources at CAMDS. Section 2.3 summarizes the methods and data used to estimate COPC emission rates for each source.

2.1 SOURCES AT TOCDF

The design and operation of TOCDF are based on the Johnston Atoll Chemical Agent Disposal System (JACADS). The demilitarization process at TOCDF involves three major steps: (1) handling and transferring chemical munitions from the Area 10 Storage facility to TOCDF, (2) disassembling and incinerating chemical munitions, and (3) managing the residual waste materials.

Chemical munitions and agents transferred from the Area 10 Storage facility are unloaded at the container handling building (CHB). The munitions and agents are disassembled and incinerated in the munitions demilitarization building (MDB), which contains the four incinerators (LIC 1, LIC 2, MPF, and DFS). The incineration units can, and commonly do, operate simultaneously. The LICs destroy liquid agent drained from munitions and spent decontamination solution. The MPF treats the metal components of the munitions after the bulk of the chemical agent has been removed. The DFS is designed to treat chemical munitions that contain energetic components (propellants, bursters, and explosives) after the bulk of the chemical agent has been removed.

The MDB is maintained under negative pressure by the HVAC system. Process vessels in the pollution abatement system (PAS) building and the process utilities building (PUB) are also maintained under negative pressure. Leaking munitions are not handled in the CHB. Therefore, fugitive emissions (to the atmosphere) from the systems are unlikely. Therefore, potential fugitive emissions were not evaluated separately from the TOCDF HVAC system.

Emissions from each unit are treated by a separate PAS in the PAS building before they are vented to a common stack. PAS brines may be treated in the BRA, but the BRA does not currently operate. Therefore, the brines are sent off site for treatment and disposal. The BRA, except for the BRA burner and baghouses, is located inside the PUB.

2.2 SOURCES AT CAMDS

CAMDS began operations in September 1979 as a research activity designed to develop methods and procedures—primarily employing various types of incineration—to destroy chemical munitions stockpiled at DCD and other U.S. Army depot locations such as Johnston Atoll, Umatilla Army Depot, and Pine Bluff Arsenal. Since the RCRA Part B permit application was submitted, only the MPF has operated; the LIC and DFS are currently not in operation. CAMDS anticipates that the MPF will be used in the future to destroy (1) off-specification VX-hydrolysate, (2) pretreated ton containers that previously contained lewisite, (3) empty ton containers, and (4) miscellaneous wastes. The MPF may also be used to treat debris from Assembled Chemicals Weapons Assessment (ACWA) support work and debris from ACWA research and development that is generated at CAMDS. Facility personnel have indicated that the LIC, DFS, and MPF will be used in the future to destroy stockpiles of munitions stored at DCD. The HHRA assumes that CAMDS will be used to complete this mission (in other words, it assumes continuous operations).

The demilitarization process at CAMDS involves three major steps: (1) handling and transferring chemical munitions from the Area 10 Storage facility to CAMDS, (2) disassembling and incinerating chemical munitions, and (3) managing waste materials that remain after incineration. At CAMDS, the MPF and LIC are housed within the MPF Building Complex, which also includes the MPF, LIC, Multipurpose Demilitarization Machine, Multipurpose Demilitarization Facility, Bulk Item Facility, Residual Storage Area, and Central Decontamination Supply operations. These structures are all joined and share interior walls. Each area is independently ventilated by ducting that leads to the HVAC filter farm, which is located within the East Utilities Building complex, east of the DFS Building Complex.

The DFS Building Complex is located in a separate building east of the MPF Building Complex. The DFS Building Complex includes the DFS, Unpack Area, Explosive Containment Cubicle, Segregation Area, and Filter 18. Each area is independently ventilated by ducting that leads to the HVAC filter farm.

The DFS may operate at the same time as either the MPF or LIC, but the MPF and the LIC cannot operate at the same time. Because the CAMDS MPF and LIC cannot be used to treat chemical munitions simultaneously, only the CAMDS MPF was evaluated in the HHRA as being representative of both units. Emissions from the DFS are treated by a separate PAS before they are vented to a separate stack. Emissions from the MPF and LIC are treated by a common PAS before they are vented to a common stack. PAS byproducts (brines) are then collected for off-site disposal. The CAMDS BRA is not in operation and will not be used to treat hazardous waste until a compliance test can be completed to demonstrate the current configuration of the BRA drum dryers and "whirlwet" PAS.

2.3 ESTIMATION OF EMISSION RATES

COPC emission rates for use in the risk assessment were calculated based on (1) available trial burn test and test burn data from TOCDF and CAMDS (eight scenarios), or (2) emission rates from trial burn tests for similar units at another facility (CAMDS, TOCDF, or JACADS) when actual trial burn or test burn data were not available (10 scenarios). Available data include results from the trial burn test for the TOCDF GB campaign (all furnaces), the CAMDS MPF GB and VX campaigns, and the CAMDS DFS VX and sulfur mustard campaigns.

During the COPC selection process, 393 COPCs were identified. The COPCs include (1) any compounds that had been a target analyte during trial burn tests at TOCDF, CAMDS, or JACADS (detected or nondetected), and (2) any compound that had been reported as a tentatively identified compound (TIC) during trial burn tests at TOCDF, CAMDS, or JACADS. Of these 393 COPCs, 171 were evaluated quantitatively in the risk assessment using either COPC-specific fate, transport, and toxicity data, or surrogate data (primarily for dioxins and polychlorinated biphenyls [PCB] reported as homologue totals). The 122 COPCs that were not evaluated quantitatively include (1) tentatively identified compounds (TIC); (2) volatile organic compounds (VOC) and semivolatile organic compounds (SVOC) that are not components of the waste feed and are not expected as products of incomplete combustion (PIC); and (3) metals that are not typically associated with risk to human health in combustor emissions (aluminum, boron, cobalt, copper, manganese, phosphorus, tin, and vanadium).

All of the existing data for TOCDF are relatively current and consistent with current regulations and guidance on collection of trial burn test data for risk assessment. Some of the data for CAMDS (as well as some of the data for JACADS used for extrapolation) are slightly more dated. However, these data sets include reliable information on the emission rates of COPCs that typically affect the outcome of the risk assessment process (that is, dioxins, phthalate esters, PAHs, and mercury). As discussed in Section 4.3.2.1, data on hexavalent chromium are not available for any of the data sets.

COPC-specific emission rates were estimated for the sources evaluated in the risk assessment. Trial burn data for GB were used to calculate emission rates for the sources at TOCDF. Some data were also available from test burns at CAMDS. In the absence of source- and agent-specific emissions data, emission rates were calculated by extrapolation from other facilities and other sources. Table 2-1 summarizes the basis for the source-specific emission rates for each agent campaign, the use of extrapolated data, and COPCs detected for each source.

TABLE 2-1 BASIS OF SOURCE-SPECIFIC EMISSION RATES			
Unit	**Agent**	**Basis of Emission Rates**	**Detected Compounds**
TOCDF			
DFS	VS	• Emission rates (ER) extrapolated from CAMDS DFS VX trial burn data. • Non-detected compounds evaluated at detection limits. • Used TOCDF DFS GB data for PCBs without extrapolation. • TOCDF specific upset correction factors incorporated into ERs.	• Numerous VOCs, benzoic acid, butylbenzylphthalate, di-n-octyl phthalate, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, diethyl phthalate, 3,3'-dichlorobenzidine, 2,4-dichlorophenol • Several dioxin congeners • Barium, cadmium, lead
DFS	GB	• ERs developed from TOCDF GB DFS trial burn data • Non-detected compounds evaluated at detection limits. • TOCDF-specific upset correction factors incorporated into ERs.	• Numerous VOCs, acetophenone, dimethyl phthalate • Total dichlorobiphenyls, total trichlorobiphenyls • Barium, chromium, lead, zinc
DFS	Sulfur Mustard	• ERs extrapolated from JACADS DFS GB trial burn data. • Non-detected compounds evaluated at detection limits. • TOCDF specific upset correction factors incorporated into ERs..	• Numerous VOCs, acetophenone, benzoic acid, benzyl alcohol, bis(2-ethylhexyl)phthalate, dimethyl phthalate, 2,4,6-trichlorophenol • Total trichlorobiphenyls, total trichlorobiphenyls • Barium, cadmium, chromium, lead, mercury, nickel, thallium, zinc
MPF	Sulfur Mustard	• ERs extrapolated from JACADS MPF HD trial burn data. • Non-detected compounds evaluated at detection limits. • TOCDF-specific upset correction factors incorporated into ERs.	• Methylene chloride • Antimony, arsenic, barium, cadmium, chromium, lead, zinc
MPF	GB	• ERs developed from TOCDF GB MPF trial burn data. • Non-detected compounds evaluated at detection limits. • TOCDF-specific upset correction factors incorporated into ERs.	• Numerous VOCs, bis(2-ethylhexyl)phthalate, dimethyl phthalate, phenanthrene • Several dioxin congeners
MPF	VX	• ERs extrapolated from CAMDS MPF VX trial burn data. • Non-detected compounds evaluated at detection limits. • TOCDF-specific upset correction factors incorporated into ERs.	• Benzoic acid, benzyl alcohol, bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, diethyl phthalate, dimethyl phthalate, 2,4-dinitrotoluene, 2,6-dinitrotoluene, naphthalene, phenol • Several dioxin congeners • Antimony, barium, cadmium, lead, mercury, thallium, zinc
LIC 1 and LIC 2	GB	• ERs based on TOCDF GB LIC 1 and LIC 2 trial burn data. • Non-detected compounds evaluated at detection limits. • ERs for metals based on November 1998 metals mini-burn. • TOCDF-specific upset correction factors incorporated into ERs.	• Numerous VOCs, acetophenone, benzoic acid, bis(2-ethylhexyl)phthalate, dimethyl phthalate, phenol • Total TCDD, 2,3,7,8-TCDF • Antimony, barium, cadmium, chromium, lead, mercury, nickel, silver, zinc
LIC 1 and LIC 2	HD	• ERs extrapolated from JACADS LIC HD trial burn data. • Non-detected compounds evaluated at detection limits. • TOCDF-specific upset correction factors used incorporated into ERs.	• Numerous VOCs, benzoic acid, benzyl alcohol, dimethyl phthalate • All dioxin congeners • Arsenic, chromium, lead, mercury, selenium, thallium, zinc
LIC 1 and LIC 2	VX	• ERs extrapolated from JACADS LIC VX trial burn data. • Non-detected compounds evaluated at detection limits. • TOCDF-specific upset correction factors incorporated into ERs.	• Numerous VOCs, benzoic acid, benzyl alcohol, bis(2-ethylhexyl)phthalate, dimethyl phthalate, 2-methylphenol, 4-methylphenol, naphthalene • One dioxin homologue • Barium, chromium, zinc
BRA	NA	• ERs developed from TOCDF BRA trial burn data. • TOCDF-specific upset correction factors incorporated into ERs.	• Barium, cadmium, chromium, lead, nickel, silver, zinc
HVAC	GB, VX, and Sulfur Mustard	• Based on 20 percent of agent 8-hour time weighted average and maximum stack gas flow rate. • TOCDF-specific upset correction factors used.	Not applicable

TABLE 2-1 (Continued) BASIS OF SOURCE-SPECIFIC EMISSION RATES			
Unit	**Agent**	**Basis of Emission Rates**	**Detected Compounds**
CAMDS			
DFS	Sulfur Mustard	• ERs developed from CAMDS DFS sulfur mustard trial burn data. • Non-detected compounds evaluated at detection limits. • Default upset correction factors incorporated into ERs.	• Numerous VOCs, benzoic acid, bis(2-ethylhexyl)phthalate, di-n-butyl phthalate • Several dioxin homologues • Arsenic, barium, cadmium, chromium, lead, mercury, nickel, silver
DFS	VX	• ERs developed from CAMDS DFS VX trial burn data. • Non-detected compounds evaluated at detection limits. • Default upset correction factors incorporated into ERs.	• Numerous VOCs, benzoic acid, butylbenzylphthalate, di-n-octyl phthalate, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, diethyl phthalate, 3,3'-dichlorobenzidine, 2,4-dichlorophenol • Several dioxin homologues • Barium, cadmium, lead
DFS	GB	• ERs extrapolated from TOCDF DFS GB trial burn data. • Non-detected compounds evaluated at detection limits. • Default upset correction factors incorporated into ERs.	• Numerous VOCs, acetophenone, dimethyl phthalate • Barium, chromium, lead, zinc
MPF	GB	• ERs developed from CAMDS MPF GB trial burn data. • Non-detected compounds evaluated at detection limits. • Default upset correction factors incorporated into ERs.	• Numerous VOCs, benzoic acid, bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, diethyl phthalate, dimethyl phthalate, phenol • Several dioxin congeners • Arsenic, chromium, lead, selenium, silver
MPF	VX	• ERs developed from CAMDS MPF VX trial burn data. • Non-detected compounds evaluated at detection limits. • Default upset correction factors incorporated into ERs.	• Benzoic acid, benzyl alcohol, bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, diethyl phthalate, dimethyl phthalate, 2,4-dinitrotoluene, 2,6-dinitrotoluene, naphthalene, phenol • Several dioxin congeners • Antimony, barium, cadmium, lead, mercury, thallium, zinc
MPF	Sulfur Mustard	• ERs extrapolated from JACADS MPF sulfur mustard trial burn data. • Non-detected compounds evaluated at detection limits. • Default upset correction factors incorporated into ERs.	• Methylene chloride • Antimony, arsenic, barium, cadmium, chromium, lead, zinc
HVAC	GB, VX, and Sulfur Mustard	• ERs set equal to 20 percent of agent 8-hour time weighted average and maximum stack gas flow rate.	Not applicable

Notes:

BRA	Brine reduction area
CAMDS	Chemical Agent Munitions Disposal System
DFS	Deactivation furnace
GB	Isopropyl methylphosphonofluoridate
HVAC	Heating, ventilation, and air conditioning filter system
JACADS	Johnston Atoll Chemical Agent Disposal System
LIC	Liquid incinerator
MPF	Metal parts furnace
PCB	Polychlorinated biphenyl
TOCDF	Tooele Chemical Agent Disposal Facility
VX	O-ethyl-S-[2-diiospropylaminoethyl]-methyl phosphonothiolate

3.0 EXPOSURE ASSESSMENT

The protocol describes the exposure setting, the exposure scenarios, and the mathematical procedures, assumptions, and U.S. EPA-recommended (or "default") parameters used to quantify exposure. Sections 3.1 and 3.2 summarize the exposure setting and the exposure scenarios evaluated. Section 3.3 presents the site-specific fate, transport, and exposure parameter values used in the HHRA, including parameters that deviate from the protocol, are not reported in the protocol, or deviate from U.S. EPA default values. Sections 3.4 through 3.8 discuss procedures used to specifically evaluate PCBs, dioxins, lead, chromium, and mercury. These sections discuss (1) the specific procedures used to evaluate these compounds, and (2) the limitations associated with the available emissions data.

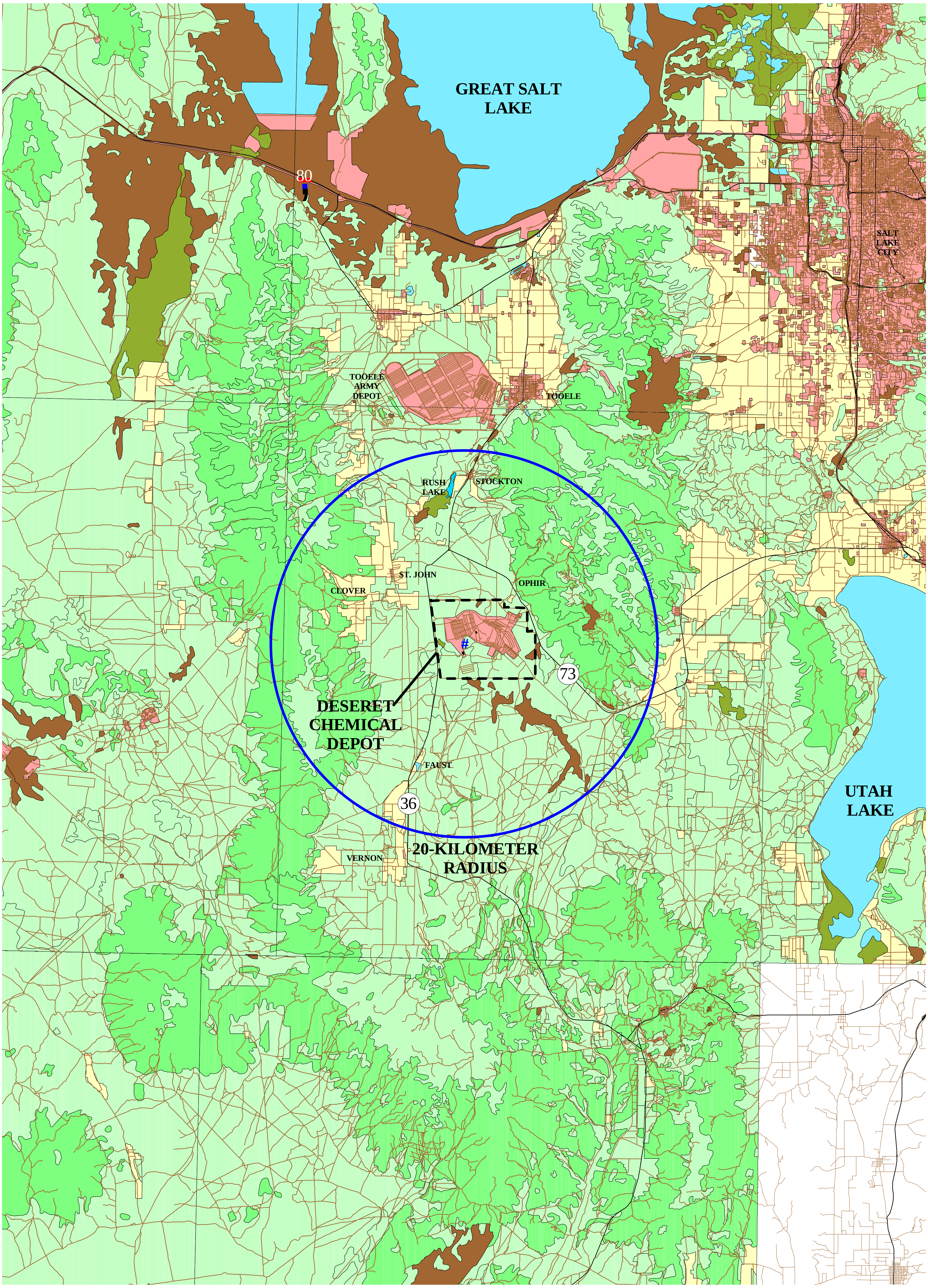
3.1 EXPOSURE SETTING

DCD is a 19,400-acre facility located in the moderately flat and arid Rush Valley in Tooele County, Utah. Rush Valley is surrounded by Tooele Valley to the north, the Oquirrh Mountains to the east, the West Tintic and Sheeprock Mountains to the south, and the Stansbury and Onaqui Mountains to the west (Figure 3-1). DCD is 50 miles southwest of Salt Lake City, 20 miles south of the City of Tooele and the Tooele Army Depot, and 38 miles northwest of the City of Provo. The largest towns inside the 20 kilometer (km) radius assessment area include Faust, Clover, St. John, Ophir, and Stockton. The main types of land use include agricultural areas, forested areas in the mountains east and west of the facility, and rangeland.

Four water bodies were evaluated in the risk assessment: Soldier Creek, Rush Lake, the SunTen water ski ponds, and Rainbow Reservoir. Soldier Creek, which flows into Rush Lake during spring snowmelt, is the source of drinking water for the town of Stockton. The drinking water pathway was evaluated for the subsistence rancher and resident scenarios. Fishing and incidental ingestion of water were evaluated for Rush Lake. Incidental ingestion of water was also evaluated for the SunTen water skier scenario; the ponds are several kilometers west of the facility. Ingestion of fish was evaluated for Rainbow Reservoir, a small pond in the northeast corner of the DCD grounds that the U.S. Army may open to the public for recreational fishing (see Figure 3-2).

Special subpopulations were qualitatively evaluated in the risk assessment. Special subpopulations include schools, hospitals, nursing homes, and daycare facilities. On July 20, 2001, the yellow pages at http://yp.yahoo.com was searched for names and locations of special subpopulations using keywords for each of the five towns in the study area listed above. Based on the listings in the Yahoo yellow pages, there are no special subpopulations in the assessment area (20-km radius from DCD). The nearest subpopulations are as follows:

- The nearest school is Cedar Valley Elementary School in the town of Cedar Valley, 25 km east-northeast of DCD (measured from the center of the facility).
- The nearest hospital is Tooele County Hospital in Tooele, 25 km north of DCD.
- The nearest nursing home is Tooele Valley Nursing Home in Tooele, 25 km north of DCD.
- The nearest day care listed is South Valley Care Center in West Jordan, about 40 km northeast of DCD.



LEGEND

LAND USE CLASSIFICATION
- AGRICULTURAL
- BARREN LAND
- FOREST LAND
- URBAN OR BUILT-UP LAND
- MIXED RANGELAND
- WATER
- WETLAND

- DESERET CHEMICAL DEPOT BOUNDARY
- # CENTRIC POINT FOR ATMOSPHERIC DISPERSION MODELING
- 36 STATE HIGHWAY
- INTERSTATE HIGHWAY

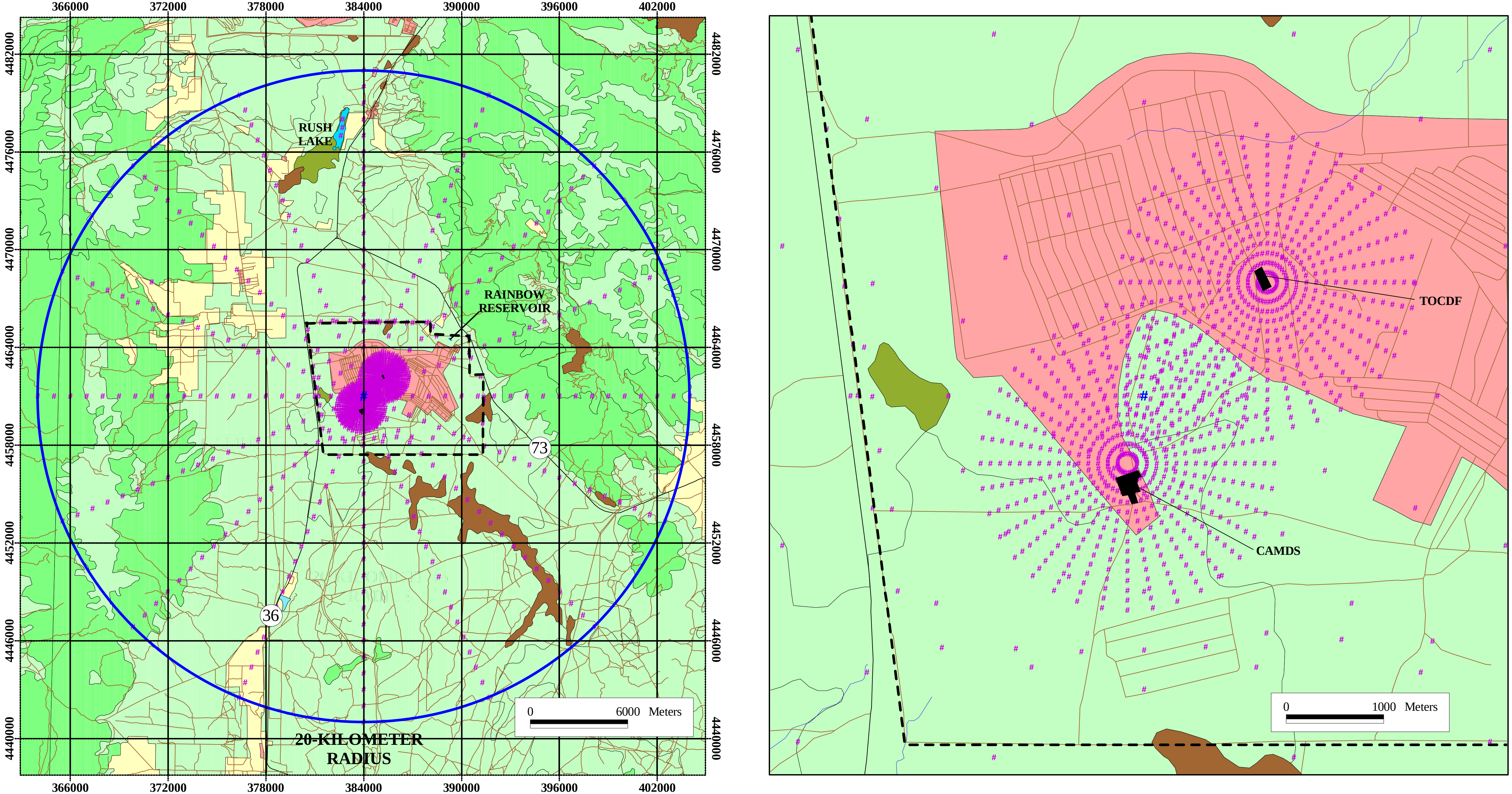
NOTES: 20-KILOMETER RADIUS IS FROM A POINT CENTERED ON THE TOCDF AND CAMDS FACILITIES.
GRID IS BASED ON THE NORTH AMERICAN DATUM 1927 1000-METER UNIVERSAL TRANSVERSE MERCATOR COORDINATE SYSTEM.
LAND USE CLASSIFICATION FOR THE LOWER RIGHT CORNER OF THE MAP COULD NOT BE DISPLAYED DUE TO A FILE ERROR.

SOURCES: U.S. ENVIRONMENTAL PROTECTION AGENCY, 1977, AND THE STATE OF UTAH DIVISION OF INFORMATION TECHNOLOGY SERVICES AUTOMATED GEOGRAPHIC REFERENCE CENTER, JULY 2000.

UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY
DIVISION OF SOLID AND HAZARDOUS WASTE

FIGURE 3-1
SITE LOCATION MAP

TETRA TECH EM INC.



NOTES: 20-KILOMETER RADUS IS FROM A POINT CENTERED ON THE TOCDF AND CAMDS FACILITIES.
GRID IS BASED ON THE NORTH AMERICAN DATUM 1927 1000-METER UNIVERSAL TRANSVERSE MERCATOR COORDINATE SYSTEM.
CAMDS = CHEMICAL AGENT MUNITIONS DISPOSAL SYSTEM
TOCDF = TOOELE CHEMICAL AGENT DISPOSAL FACILITY

SOURCES: U.S. ENVIRONMENTAL PROTECTION AGENCY, 1977, AND THE STATE OF UTAH DIVISION OF INFORMATION TECHNOLOGY SERVICES AUTOMATED GEOGRAPHIC REFERENCE CENTER, JULY 2000.

LEGEND

LAND USE CLASSIFICATION
- AGRICULTURAL
- BARREN LAND
- FOREST LAND
- URBAN OR BUILT-UP LAND
- MIXED RANGELAND
- WATER
- WETLAND

DESERET CHEMICAL DEPOT BOUNDARY

COORDINATE SYSTEM USED FOR AIR DISPERSION MODELING

36 STATE HIGHWAY

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UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY DIVISION OF SOLID AND HAZARDOUS WASTE

FIGURE 3-2
LAND USE AND LAND COVER MAP

TETRA TECH EM INC.

The locations of the on-site and off-site receptor locations evaluated in the air dispersion modeling are shown on Figure 3-2. A receptor location is an X,Y (longitude, latitude) coordinate for which the air dispersion modeling calculates the concentrations of COPCs in air (vapor, particle, and particle-bound) and the deposition rate for each COPC. The HHRA protectively evaluated the "maximum exposed individual" (MEI), which is the receptor location (specific to each exposure scenario) that presents the highest risk or hazard value for each exposure scenario evaluated. The MEI location does not necessarily correspond to a particular land use or exposure scenario. The receptor location with the maximum off-site point of impact (specific to each exposure scenario) was used to assess risk and hazard to all off-site receptors, which ensured that the risk assessment considered the potential risks to human receptors that populate all off-site areas. Likewise, the receptor location with the maximum on-site point of impact was used to assess risk and hazard for the DCD on-site worker scenario to ensure that all on-site workers were considered in the risk assessment. The protocol describes how the maximum points of impact were identified.

3.2 EXPOSURE SCENARIOS

The risk assessment evaluated exposure scenarios for: (1) the subsistence rancher adult and child, (2) the resident adult and child, (3) the on-site DCD worker, (4) the recreationist adult and child (for both the SunTen water ski lakes and Rush Lake), and (5) the fisher adult and child (for Rainbow Reservoir). As discussed in the protocol, the risk assessment evaluated all exposure pathways recommended by U.S. EPA (1998), as follows:

- Inhalation (acute risk) was evaluated as a current exposure for the resident adult and child, on-site DCD worker, and the subsistence rancher adult and child.
- Incidental ingestion of soil was evaluated as a current exposure for the resident adult and child and the on-site DCD worker.
- Ingestion of drinking water from surface water sources (Soldier Creek) was evaluated as a current exposure for the resident adult and child and the subsistence rancher adult and child.
- Incidental ingestion of surface water (Rush Lake) was evaluated as a current exposure for the recreationist adult and child.
- Ingestion of homegrown produce and farm-raised beef, sheep, poultry, and eggs was evaluated as a current exposure for the subsistence rancher adult and child.
- Ingestion of farm-raised cow's milk and pork was evaluated as a potential future exposure for the subsistence rancher adult and child.
- Ingestion of fish (Rush Lake) was evaluated as a potential future exposure for the recreational adult and child.
- Ingestion of dioxins in breast milk by an infant was evaluated as a current exposure for the resident child, the subsistence rancher child, and the on-site worker.

In response to public comments on the protocol, additional pathways were evaluated:

- Ingestion of mutton (as a current exposure) for the subsistence rancher adult and child

- Ingestion of goat's milk (as a potential future exposure) for the subsistence rancher adult and child

- Ingestion of fish from Rainbow Reservoir for the fisher adult and child (evaluated as a future scenario)

- Incidental ingestion of surface water at SunTen water ski lakes for the recreationist adult and child (evaluated as a current scenario)

The risk assessment also evaluated the combined risk to a rancher adult who is also an on-site worker at DCD.

3.3 FATE, TRANSPORT, AND EXPOSURE PARAMETERS

COPCs were identified using U.S. EPA (1998) procedures from among the chemicals analyzed in trial burn tests. The exposure assessment used fate and transport parameter values recommend in U.S. EPA (1998). These parameter values are presented in the protocol. Section 3.3.1 presents the parameters for the agents. Section 3.3.2 presents the exposure parameters used to evaluate ingestion of mutton and goat's milk. Section 3.3.3 presents the site-specific climatic and water body information used in the HHRA.

3.3.1 Parameter Values for GB, VX, and Sulfur Mustard

The fate, transport, and toxicity of GB, VX, and sulfur mustard were quantitatively evaluated with parameter values available in the TOCDF *Screening Risk Assessment* (A.T. Kearney [ATK] 1996) and from the National Library of Medicine Hazardous Substances Data Bank available on-line at http://toxnet.nlm.nih.gov/. In addition, some parameter values were calculated using equations available in U.S. EPA (1998). The parameter values are listed in Table 3-1.

3.3.2 Evaluation of Mutton and Goat's Milk Pathways for the Subsistence Rancher

The mutton and goat's milk pathways for the subsistence rancher were quantitatively evaluated using food and media ingestion rates (for the sheep and goats) identified from available sources. Concentrations of COPCs in mutton and goat's milk were calculated by substituting food and media ingestion rates for sheep and goats for the corresponding values in the equations for beef cattle (Equation 5-22 in U.S. EPA 1998) and cow's milk (Equation 5-24 in U.S. EPA 1998). Default COPC biotransfer factors for beef and cow's milk were assumed to be representative for mutton and goat's milk. Sections 3.3.2.1 and 3.3.2.2 discuss the procedures used to estimate food and media ingestion rates for sheep and goats.

3.3.2.1 Ingestion of Mutton

To estimate ingestion of food by sheep, it was assumed that the receptor consumed equal parts of forage, silage, and grain. According to the U.S. Department of Agriculture (USDA [2000]), the average live weight of sheep slaughtered in the U.S. in 1999 was 133 pounds (60.33 kilograms [kg]).

TABLE 3-1 FATE, TRANSPORT, AND TOXICITY PARAMETERS FOR GB, VX, AND SULFER MUSTARD				
Parameter	**Units**	**GB**	**VX**	**Sulfur Mustard**
Molecular weight (MW)	g/mole	140.09	267.37	159.07
Melting point of chemical (T_m)	K	216.15	323.15	286.5
Vapor pressure (Vp)	atm	2.9	7.0E-04	0.09
Solubility (S)	mg/L	0	3.0E+04	0.684
Henry's Law constant (H)	atm-m^3/mole	4.9E-07	2.4E-10	2.2E-05
Diffusivity of COPC in air (D_a)	cm^2/s	0.0693	0.0449	0.0636
Diffusivity of COPC in water (D_w)	cm^2/s	8.03E-06	5.2E-06	7.37E-06
Octanol-water partition coefficient (K_{ow})	Unitless	5.25	123.03	23.44
Soil organic carbon-water partition coefficient (K_{oc})	mL water/g soil	5.159	60.423	16.581
Soil-water partition coefficient (Kd_s)	cm^3 water/g soil	3.2E-02	7.6E-01	1.41E-01
Suspended sediments-surface water partition coefficient (Kd_{sw})	L water/kg suspended sediment	2.4E-01	5.7	1.1
Bed sediment/sediment pore water partition coefficient (Kd_{bs})	cm^3 water/g bottom sediment	1.3E-01	3.0	5.8E-01
COPC loss constant caused by abiotic and biotic degradation (ksg)	Yr^{-1}	NA	NA	NA
Fraction of COPC air concentration in vapor phase (F_v)	Unitless	1.0	1.0	1
Root concentration factor (RCF)	(µg COPC/g DW plant)/ (µg COPC/mL soil water)	9.3E-01	2.1	1.2
Plant-soil bioconcentration factor for COPC in belowground produce ($Br_{rootveg}$)	Unitless	29.06	2.76	8.57
Plant-soil bioconcentration factor for COPC in aboveground produce ($Br_{leafyveg}$)	Unitless	14.85	2.4	6.25
Plant-soil bioconcentration factor for forage (Br_{forage})	Unitless	14.85	2.4	6.25
COPC air-to-plant biotransfer for aboveground produce ($Bv_{leafyveg}$)	Unitless	1.7	9.9E+04	1.8E-01
COPC air-to-plant biotransfer factor for forage (Bv_{forage})	Unitless	1.7	9.9E+04	1.8E-01
Biotransfer factor for milk (Ba_{milk})	day/kg FW tissue	4.2E-08	9.8E-07	1.9E-07
Biotranfer factor for beef (Ba_{beef})	day/kg FW tissue	1.3E-07	3.1E-06	5.9E-07
Biotransfer factor for pork (Ba_{pork})	day/kg FW tissue	1.56E-07	3.72E-06	7.08E-07
Bioconcentration factor for fish (BCF_{fish})	Unitless	1.4	18	4.8
Bioaccumulation factor for fish (BAF_{fish})	L/kg FW tissue	1.4	18	4.8
Biota-to-sediment accumulation factor ($BSAF_{fish}$)	Unitless	1.4	18	4.8
Reference dose (RfD)	mg/kg day	9.3E-06	9.3E-06	1.5E-07
Oral cancer slope factor (Oral CSF)	$(mg/kg\ day)^{-1}$	NA	NA	7.7
Reference concentration (RfC)	mg/m^3	3.0E-06	3.0E-06	1.0E-04
Inhalation unit risk factor (URF_{inh})	$(µg/m^3)^{-1}$	NA	NA	2.7E-03
Inhalation cancer slope factor (Inhalation CSF)	$(mg/kg\ day)^{-1}$	NA	NA	7.9
Plant-soil bioconcentration factor for COPC in grain (Br_{grain})	Unitless	14.85	2.4	6.25
Biotransfer factor for eggs (Ba_{egg})	day/kg FW tissue	4.17E-05	9.77E-04	1.86E-04
Biotransfer factor for chicken ($Ba_{chicken}$)	day/kg FW tissue	1.04E-07	2.48E-06	4.72E-07
Inhalation reference dose (Inhalation RfD)	mg/kg day	3.0E-05	9.0E-08	9.0E-08

Notes:

atm	Atmospheres	L	Liter
cm	Centimeter	M	Meter
COPC	Compound of potential concern	µg	Microgram
DW	Dry weight	mg	Milligram
FW	Fresh weight	mL	Milliliter
g	Gram	NA	Not applicable
GB	Isopropyl methylphosphonofluoridate	S	Second
K	Kelvin	VX	O-ethyl-S-[2-diisopropylaminoethyl] methylphosphonothiolate
kg	Kilogram	yr	Year

This body weight was used as the input into an allometric equation for calculating the food ingestion rate for an herbivorous mammal (U.S. EPA 1993):

$$0.577 \times BW^{0.727} = FIR$$

where, BW = Body weight (kg)
FIR = Food ingestion rate (kg dry weight [DW] per day [d])

Based on a body weight of 60.329 kg, the food ingestion rate for sheep is 1.724 kg DW/d, which was partitioned equally among forage, silage, and grain (0.575 g DW/d per food item). A sheep's soil ingestion rate was estimated based on the fraction (4.3 percent) of soil ingested by beef cattle (U.S. EPA 1998). Based on a value of 4.3 percent soil in the diet, the soil ingestion rate for a sheep is 0.0732 kg DW/d. A rate for the ingestion of mutton by the subsistence rancher was set at 1.3 g DW/d for adults (National Livestock and Meat Board 1993) and 0.08 g DW/d for children (U.S. EPA 1989).

3.3.2.2 Ingestion of Goat's Milk

To estimate a food ingestion rate for a goat, it was assumed that the animal feeds on forage only. According to the American Dairy Goat Association (Tetra Tech 2001a), 150 pounds (68.04 kg) is the minimum weight for a dairy goat to be entered into competition. It was assumed that this value is representative for a dairy goat owned by a subsistence rancher. This body weight was used as the input into the allometric equation presented above to calculate a food ingestion rate for an herbivorous mammal. Based on a body weight of 68.04 kg, the goat food (forage) ingestion rate is 1.882 kg DW/d. The goat's soil ingestion rate was estimated based on the fraction (4.3 percent) of soil ingested by beef cattle (U.S. EPA 1998). Based on a value of 4.3 percent soil in the diet of a goat, a soil ingestion rate equal to 0.081 kg DW/d was calculated.

To estimate exposure by ingestion of goat's milk, it was assumed that the subsistence rancher entirely replaces cow's milk intake with goat's milk. Intake of goat's milk, therefore, was assumed to be the same as the default value for the ingestion of cow's milk reported by U.S. EPA (1998).

3.3.3 Climatic and Water Body Information

Information on climate and water bodies was collected to evaluate exposure pathways for four water bodies around DCD. Table 3-2 lists the site-specific climatic parameters, and Table 3-3 lists the parameters specific to each water body evaluated in the HHRA.

Watershed area is used to estimate concentrations of COPCs in the water column, bed sediment, fish, and other sinks. The effective area of each watershed was estimated in accordance with U.S. EPA (1998) guidance. The size of the effective watershed area was evaluated based on the exposure scenarios for corresponding water bodies. A small watershed was calculated for Rainbow Reservoir since surface flow into the reservoir is expected to be negligible. Soldier Creek supplies the drinking water for Stockton. The intake structure for the raw water (collected during spring snow melt) is situated in the Oquirrh Mountains east of the city. Therefore, the effective watershed based on the drainage area for the intake structure was estimated from topographic contours. The SunTen water ski pond is fed by springs. Therefore, a minimal watershed around the perimeter of the pond was estimated to account for surface water input during rain. The effective watershed for Rush Lake included the lake and the wetlands area northeast of the lake.

TABLE 3-2 SITE-SPECIFIC CLIMATIC PARAMETERS			
Parameter	**Units**	**Value**	**Reference**
Annual Precipitation	cm/yr	27.25[a]	NCDC 2000
Average Annual Irrigation	cm/yr	75[b]	Baes and others 1984
Surface Water Runoff	cm/yr	1.27	Geraghty and others 1973
Evapotranspiration	cm/yr	29.6	Water Resources Work Group 1986
Wind Velocity	m/s	4.15[c]	MRI 1999

Notes:

a Average of annual precipitation values from 1954 to 1997. Data for 1955, 1963, 1965 through 1971, 1974, and 1990 are missing.
b Value taken from a range reported in the reference cited.
c Average wind velocity for Salt Lake City, Utah, from 1986 through 1990.
cm/yr Centimeter per year
MRI Midwest Research Institute
NCDC National Climatic Data Center

TABLE 3-3 WATER BODY PARAMETERS			
Parameter	**Units**	**Value**	**Reference**
All watersheds			
USLE cover management factor	Unitless	0.1	U.S. EPA 1994
USLE rainfall factor	yr^{-1}	50	U.S. EPA 1994
Rush Lake			
Depth of water column	M	6	UDEQ 1995
Current velocity	m/s	0	Best Professional Judgment [a]
Average volumetric flow rate	m^3/yr	0	Best Professional Judgment [a]
Rainbow Reservoir			
Depth of water column	M	4.6	Tetra Tech 2000
Current velocity	m/s	0	Best Professional Judgment [a]
Average volumetric flow rate	m^3/yr	1,392,728.5	Tetra Tech 2000
Soldier Creek			
Depth of water column	M	1	Tetra Tech 2000
Current velocity	m/s	1	Tetra Tech 2000
Average volumetric flow rate	m^3/yr	320,022	Tetra Tech 2000
SunTen Ponds			
Depth of water column	M	1.2	Tetra Tech 2000
Current velocity	m/s	0	Best Professional Judgment [a]
Average volumetric flow rate	m^3/yr	0	Best Professional Judgment [a]

Notes:

a The lakes and reservoir have no surface output. Therefore, based on best professional judgment, velocity and volumetric flow rate were set to zero.
m^3/yr Cubic meter per year
m/s Meter per second
m Meter

3.3.4 Modifications in the Procedures for the Risk Assessment

The results of preliminary risk calculations as well as those of the draft risk assessment indicated that revisions to the risk assessment procedures (Tetra Tech 2001b) were warranted, as follows:

- **Estimation of Risk and Hazard**. The protocol proposed to calculate risks and hazards for all COPCs. The methodology was revised so that separate risk and hazard estimates were calculated for all COPCs and detected COPCs only.

- **Extrapolation of Ingestion Cancer Slope Factor for Chromium**. The inhalation cancer slope factor for hexavalent chromium was not extrapolated to an ingestion cancer slope factor as recommended by U.S. EPA (1998). All ingested chromium was assumed to be non-carcinogenic.

- **COPC Emission Rates**. The values for several emission rates were updated to address minor calculation and classification errors. The changes had no significant effect on the magnitude of the risk and hazard estimates reported in the draft risk assessment report (that is, COPCs with risks and hazards reported above DSHW reporting levels in the draft risk assessment report still exceed the reporting levels). The revised emission rates are presented in Appendix B.

- **Evaluation of Cumulative Risks and Hazards for TOCDF**. Similar to initial assessment of the units at CAMDS, the simple addition of unit-specific risks and hazards for each agent campaign at TOCDF resulted in a vast overestimation of cumulative risks and hazards. Therefore, weighted-average, unit-specific emission rates were used to assess cumulative risks and hazards associated with emissions at TOCDF. Emission rates were weighted based on the duration of each agent campaign compared with the total duration of all campaigns. The weighting procedure and the weighted-average emission rates are presented in Appendix C.

- **Sulfur Mustard Campaign Emission Rates for the CAMDS DFS**. For the sulfur mustard campaign, the draft risk assessment evaluated two sets of emission rates to estimate the risks and hazards associated with the CAMDS DFS. For the draft final report, a single set of emission rates was created from the highest COPC-specific emission rates listed in the two sets. The revised set of emission rates is presented in Appendix D.

- **Evaluation of Risks and Hazards for CAMDS**. The draft risk assessment evaluated agent-specific risks and hazards for each unit at CAMDS. The unit-specific risks and hazards for each agent campaign were summed to estimate cumulative risks and hazards. However, this method overestimated cumulative risks and hazards by several orders of magnitude. Therefore, unit-specific cumulative risks and hazards were evaluated using the highest, or worst-case, emission rates among the three campaigns. The set of worst-case CAMDS emission rates is presented in Appendix D.

In addition to modifications to emission rates, several exposure parameters differ from the values listed in the protocol or are not reported in the protocol.

- The inhalation exposure frequencies for the resident adult and child, subsistence rancher adult and child, and the on-site worker correspond, for each agent campaign, to the agent-specific periods of combustion, which are 7.67 years for GB, 2.47 years for VX, and 2.86 years for sulfur mustard.

3.4 EVALUATION OF POLYCHLORINATED BIPHENYLS

PCBs were evaluated in the risk assessment using two different approaches, in accordance with U.S. EPA (1998) guidance. First, to calculate the risk and hazard of all PCB congeners, total PCBs were modeled as Aroclor 1254 using a slope factor of 2 milligrams per kilogram-day because the sampling data indicated that the mixture of PCBs in the stack gas emissions contained 0.5 percent or more PCB congeners with more than four chlorine atoms (between 39 and 52 percent). U.S. EPA recommends that the fate and transport properties for Aroclor 1254 be used for modeling this type of PCB mixture because approximately 77 percent of Aroclor 1254 is composed of PCB congeners with more than four chlorine atoms.

Second, a PCB toxicity equivalence (TEQ) value was calculated for the dioxin-like coplanar PCB congeners, using the list of dioxin-like coplanar PCB congeners and toxicity equivalence factors (TEF) presented in U.S. EPA (1998) guidance. Fate and transport of the PCB TEQ was modeled based on Aroclor 1254 to calculate the average daily dose value. The slope factor for 2,3,7,8-TCDD was applied to the daily dose to estimate cancer risk from coplanar PCBs.

A summary of the PCB emission rates, TEF values, and TEQ values is presented in Appendix E. The U.S. EPA (1998) list of dioxin-like coplanar PCB congeners and the available trial burn test data are based on a 1994 World Health Organization (WHO) list of dioxin-like coplanar PCB congeners and TEF values (Ahlborg and others 1994). In 1997, WHO revised its list of dioxin-like coplanar PCB congeners and TEF values, adding one congener (3,4,4',5-tetrachlorobiphenyl), deleting two congeners (2,2',3,3',4,4',5-heptachlorobiphenyl and 2,2',3,4,4',5,5'-heptachlorobiphenyl), and decreasing (by a factor of 5) the TEF value for one congener (3,3',4,4'-tetrachlorobiphenyl) (Van den Berg and others 1998). For informational purposes, both the 1994 and 1997 WHO values are presented in Appendix E. Because all of the emission rate values for the dioxin-like coplanar PCB congeners are based on concentrations in samples of stack gas reported at the detection limits (non-detected), the differences in congeners and TEF values are not expected to significantly alter the results of the risk assessment.

3.5 EVALUATION OF DIOXINS

The carcinogenic risks of polychlorinated dibenzo(p)dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) were evaluated according to U.S. EPA (1998) guidance based on the current slope factor for 2,3,7,8-tetrachlorodibenzo(p)dioxin (TCDD) of 1.5E+05 mg/kg-day^{-1}. For this report, PCDDs and PCDFs are collectively described as “dioxins.” In September 2000, the U.S. EPA Science Advisory Board (SAB) recommended a new slope factor of 1.0E+06 (mg/kg-day)$^{-1}$ for evaluating the cancer potency of dioxins (U.S. EPA 2000). Dioxin risks based on the new slope factor were also evaluated.

3.6 EVALUATION OF LEAD

U.S. EPA has not recommended a reference concentration or reference dose to evaluate the hazard of lead. Neurobehavioral effects of lead have been observed in children with blood lead levels below those that have caused cancer in laboratory animals. For various reasons, children are more susceptible to exposures to lead than adults. Therefore, U.S. EPA has not developed a cancer slope factor for lead. According to U.S. EPA (1998) guidance, the hazard posed by lead should be evaluated by comparing estimated concentrations in soil with a concentration of 400 milligrams per kilogram (mg/kg). U.S. EPA’s IEUBK model predicts that the concentration of lead in blood will exceed 10 micrograms per deciliter in no more than 5 percent of children exposed to a concentration of lead in soil of 400 mg/kg.

Projected concentrations of lead in soil for each agent campaign were compared with the 400 mg/kg concentration to assess the potential for lead toxicity.

In addition, the maximum concentration of lead in air was estimated and compared to the National Ambient Air Quality Standard (quarterly average) of 1.5 micrograms per cubic meter ($\mu g/m^3$) (value listed on-line at http://www.epa.gov/airs/criteria.html).

3.7 EVALUATION OF CHROMIUM

As discussed in the protocol, available analytical data on chromium in emissions were limited to measurements of total concentrations of chromium; no data on speciated forms of chromium were available for the risk assessment. In the absence of this information, U.S. EPA (1998) recommends assuming that all exposure is to hexavalent chromium, the most toxic form of the element. However, U.S. EPA guidance also recognizes that this assumption probably overestimates the potential for adverse health effects from chromium because hexavalent chromium is readily converted in the environment to the less toxic, trivalent form. Therefore, the risk assessment assumed emissions were composed entirely of hexavalent chromium to evaluate the potential for adverse health effects from chromium. The risk assessment also evaluated chromium as if emissions were composed entirely of trivalent chromium to bracket risk from chromium.

In accordance with U.S. EPA (1998) guidance, hexavalent chromium was evaluated as an oral and an inhalation hazard, and as an inhalation carcinogen. It was not evaluated as an oral carcinogen because information indicates that the ingested compound does not cause cancer (DSHW 2001). Trivalent chromium was evaluated as an oral and an inhalation hazard only because it is not carcinogenic.

3.8 EVALUATION OF MERCURY

Mercury was evaluated according to U.S. EPA (1998) guidance, which recommends assuming that mercury (measured as total mercury) emissions are in inorganic forms. Mercury deposited to environmental media was also assumed to be in inorganic forms. After it is deposited, U.S. EPA (1998) methods assume a fraction of the deposited mercury is converted to methyl mercury, an organic form; the balance of the mercury is assumed to be divalent mercury. Therefore, the risk assessment evaluated both inorganic mercury, modeled as mercuric chloride, and organic mercury, modeled as methyl mercury.

4.0 RISK CHARACTERIZATION

The risk characterization was carried out to meet the following objectives of DSHW: (1) estimate and describe a range of cancer risk and non-carcinogenic hazard for each agent campaign and agent campaigns combined; (2) evaluate the uncertainties associated with the risk and hazard estimates, including the evaluation of the significance of estimated risk and hazard values that exceed DSHW reporting levels; and (3) describe the actions DSHW will take as the RCRA permitting authority to manage COPCs with risk and hazard values that exceed U.S. EPA target levels.

4.1 ESTIMATION AND DESCRIPTION OF AGENT RISK AND HAZARD

Agent risk and hazard were evaluated to estimate the potential for adverse health effects for people that (1) reside and ranch in the assessment area, (2) work at DCD, and (3) engage in recreational activities in the assessment area. Section 4.1.1 presents the TOCDF source-specific risks and hazards for each agent campaign based on the assessment of all COPCs, which includes those compounds detected in emissions and the non-detected compounds evaluated at the analytical detection limit in the stack gas. Section 4.1.2 presents the TOCDF source-specific risks and hazards for each agent campaign based on detected COPCs only. Section 4.1.3 presents the source-specific risks and hazards associated with CAMDS sources; these results are based on worst-case COPC-specific emission rates among the three agent campaigns. Section 4.1.4 presents the estimates of cumulative risks and hazards for sources at both TOCDF and CAMDS. Section 4.1.5 presents the results of the evaluation of the infant breast milk pathway. Section 4.1.6 presents the results of the evaluation of risks to the subsistence rancher based on the ingestion of ranch-raised mutton and goat's milk. Section 4.1.7 presents the results of the evaluation of acute inhalation hazards. Sections 4.1.8 through 4.1.10 discuss the results of the assessment of risks and hazards associated with PCBs, dioxins, and lead. Section 4.1.11 discusses the risk and hazard for a subsistence rancher that works and DCD.

IRAP-*h* View output was exported into a Microsoft Access® database to manage and query the information to meet report and DSHW risk management objectives. All reported risks and hazards for individual emission sources are based on the receptor locations with the greatest cumulative risks and greatest cumulative hazards. For sources with risks and hazards exceeding DSHW reporting levels, additional queries were used to identify individual COPCs with cancer risk values and hazard values that exceed DSHW reporting levels.

For the evaluation of the TOCDF sources, the range of risk and hazard is bracketed by an upper value and a lower value. The upper value is set as the risk or hazard equal to the total risk or hazard presented by "all COPCs," which include compounds detected in one or more stack gas samples ("detects") and compounds not detected in stack gas samples ("non-detects"). At the lower end of the range, risk or hazard is equal to the total risk or hazard presented by detected COPCs only. This risk is described as "detected COPCs only." The differences between the upper and lower values are equal to the risks or hazards presented by non-detected COPCs. The risk assessment for these COPCs was based on their analytical detection limit.

The risk and hazard estimates are compared to the U.S. EPA target levels and the DSHW reporting levels. The U.S. EPA target level for carcinogenic effects of 1×10^{-5} (1E-05), or 1 in 100,000, is the same target level used for the TOCDF screening risk assessment (ATK 1996). The 1E-05 value is within the range outlined in the National Contingency Plan and is consistent with existing DSHW rules and policies. The value of 1E-05 is interpreted to mean that at the calculated exposure, a person's chance of getting cancer is no higher than 1 in 100,000. The U.S. EPA target level for non-carcinogenic effects is a hazard quotient (HQ) or hazard index (HI) of 0.25, depending on whether a single compound or a group of compounds is being evaluated; it is the same target level used for the TOCDF screening risk assessment (ATK 1996). Although no adverse health effects are predicted if the HQ or HI is less than 1, the U.S. EPA target level of 0.25 (which is four times more protective) is selected to account for potential adverse effects from existing exposures that do not originate at DCD. If the calculated values for carcinogenic and non-carcinogenic endpoints are less than the target levels, potential exposures to emissions are considered acceptable. A calculated endpoint that exceeds the target level does not indicate an unsafe action or an unacceptable risk, but indicates that additional evaluation or mitigation is warranted.

The risk and hazard values were also compared with DSHW reporting levels to interpret the results of the risk characterization. Only the risk and hazard values that exceed DSHW reporting levels are reported in the text. The complete results are provided in the appendices. The DSHW reporting levels are 10 times lower (more stringent) than the target levels recommended by U.S. EPA. The DSHW reporting level for cancer risk is 1E-06 (one excess case of cancer in one million individuals), and the reporting level for adverse non-carcinogenic effects is an HI of 0.025. An HI of 1 indicates that exposure to emissions may cause an adverse effect to a population; the DSHW reporting level is 40 times lower.

4.1.1 TOCDF Risks and Hazards from All COPCs

Agent-specific IRAP-*h* View iterations with all COPCs (detected and non-detected COPCs) were completed for all exposure scenarios to:

- Calculate agent-specific risk and hazard values
- Identify specific COPCs that present risk or hazard that exceeds DSHW reporting levels and U.S. EPA target levels.

One U.S. EPA default pathway is ingestion by the subsistence rancher of home-produced meat (beef, poultry, and pork), eggs, and cow's milk. Risk from ingestion of mutton and goat's milk was not added to the risk from the U.S. EPA default scenarios because the addition violates mass balance, overcounting the risk. The exposure factors for the U.S. EPA default scenarios would require modification to alleviate this violation. Therefore, the mutton and goat's milk pathways were evaluated separately to ensure that the risk assessment is consistent with DSHW policy to use U.S. EPA-recommended exposure factors for ingestion of beef, poultry, pork, eggs, and cow's milk. Section 4.2 discusses the evaluation of the mutton and goat's milk pathways.

The "all COPCs" analysis indicates that the agent-specific risks and hazards for several exposure scenarios exceed DSHW reporting levels and, in some cases, U.S. EPA target levels. **In general, non-detected COPCs present most or all of the risks and hazards for these exposure scenarios**. The following non-detected COPCs (not detected in emissions and evaluated at their stack gas analytical detection limits) present risk or hazard that exceed DSHW reporting levels for one or more exposure scenario evaluated in the risk assessment:

- Ethyl methanesulfonate (EMS)
- Total mercury (modeled as mercuric chloride)
- Total mercury (modeled as methyl mercury)
- Di-n-octylphthalate (DNOP)
- Sulfur mustard

- Total chromium, modeled as hexavalent chromium

- Polycyclic aromatic hydrocarbons

  - Benzo(a)pyrene
  - Dibenz(a,h)anthracene
  - Indeno(1,2,3-cd)pyrene

Two detected COPCs evaluated, DNOP and total mercury (modeled as methyl mercury), presented hazard above the DSHW reporting level for one or more scenarios.

Dioxin emissions (based on a 2,3,7,8-TCDD TEQ value) from TOCDF for the sulfur mustard campaign present a cancer risk of 3E-06 for the subsistence rancher adult, which exceeds the DSHW reporting level of 1E-06. The risk value was calculated using emission rates based mainly on non-detected congeners. Most of the risk is due to emissions from the LIC 1 and LIC 2 units, each of which present risk equal to 1E-06. For these units, the individual 2,3,7,8-TCDD TEQ values for the penta-substituted congeners are the highest (based on non-detections). Only octa-substituted congeners were detected in emissions, however. Based on the preponderance of non-detected congeners in emissions, dioxins were evaluated as a non-detected COPC for the sulfur mustard campaign.

The sections below present the source-specific "all COPCs" cumulative cancer risks and HI values that exceed the DSHW reporting levels of 1E-06 and 0.025; these values are tabulated for each exposure scenario. Risks and hazards are specific to each agent campaign. Risk values are reported to one significant digit; HI values are reported to two significant digits. In these tables, the source-specific risks and hazards are tabulated for all COPCs. The source-specific risks and hazards are summed to represent the total risk and total hazard for each exposure scenario. The total risks and hazards are based on source-specific risks and hazards, including sources with values less than the DSHW reporting levels. Therefore, the totaled values may not equal the sums of the values for sources listed in the table. The source-specific receptor location that corresponds to maximum cancer risk and hazard for each exposure scenario is also listed.

4.1.1.1 GB Campaign

The cancer risks associated with treatment of GB at one or more TOCDF sources exceed the DSHW reporting level of 1E-06 for the adult and child subsistence rancher scenarios, the adult and child resident scenarios, and the on-site worker scenario (Table 4-1). The HI values associated with treatment of GB at one or more TOCDF sources exceed the DSHW reporting level of 0.025 for the adult and child subsistence rancher scenarios, the adult and child resident scenarios, the on-site worker scenario, the adult and child recreationist scenarios, and the adult and child fisher scenarios (Table 4-2).

For several sources, the risks and hazards for the adult and child subsistence rancher scenarios, the adult and child recreationist scenarios, and the adult and child fisher scenarios also exceed U.S. EPA target levels for cancer risk and hazard.

For the adult and child subsistence rancher scenarios, emissions from the TOCDF MPF present the highest cancer risk (2E-04 for the adult rancher) and the highest HI (1,000 for the child rancher) values. Excess risk to the subsistence rancher adult for the MPF is attributed to PAHs (listed above) and EMS. DNOP poses more than 99 percent of the hazard to the subsistence rancher child for the MPF.

COPC-specific risks and hazards for other sources at TOCDF exhibit similar patterns. The IRAP-*h* View output file for the adult and child subsistence rancher scenario is presented in Appendix F-1.

TABLE 4-1
CANCER RISKS FOR TOCDF SOURCES THAT EXCEED DSHW REPORTING LEVEL FOR TREATMENT OF GB — ALL COPCs

Exposure Scenario	Receptor Location	Source	Cancer Risk	
			Adult	Child
Subsistence Rancher	32	DFS	7E-05	2E-05
		LIC 1	4E-05	1E-05
		MPF	2E-04	5E-05
		LIC 2	8E-05	2E-05
		Total Cancer Risk	**4E-04**	**1E-04**
Resident	32	DFS	1E-06	<1E-06
		MPF	3E-06	2E-06
		LIC 2	1E-06	1E-06
		Total Cancer Risk	**7E-06**	**5E-06**
On-Site Worker	16	MPF	2E-06	NE
		Total Cancer Risk	**3E-06**	**NE**
Rush Lake Recreationist	NA	No source with risk > 1E-06	– –	– –
		Total Cancer Risk	**2E-06**	**<1E-06**

Notes:

COPC	Compound of potential concern
DFS	Deactivation furnace system
DSHW	Utah Department of Environmental Quality Division of Solid and Hazardous Waste
GB	Isopropyl methylphosphonofluoridate
LIC	Liquid incinerator
MPF	Metal parts furnace
NA	Not applicable for water bodies. See text for discussion.
NE	Not evaluated for on-site worker scenario.
TOCDF	Tooele Chemical Agent Disposal Facility

For the adult and child resident scenarios, the calculated cancer risk and HI values exceed the DSHW reporting levels; however, the risks and hazards were less than the U.S. EPA target levels. Emissions from the TOCDF MPF present the highest cumulative risk values for the adult (3E-06) and child (2E-06) resident scenarios. Emissions from the TOCDF BRA present the only source-specific HI values (0.042 for the adult and 0.14 for the child) that exceed the DSHW reporting level. For these scenarios, total mercury (modeled as mercuric chloride) emissions result in HQs that exceed the DSHW reporting level of 0.025. The maximum cancer risk and HI values are associated with receptor location 32 (Figure 4-1). The IRAP-*h* View output file for the adult and child resident scenarios is presented in Appendix F-2.

TABLE 4-2 HAZARD INDICES FOR TOCDF SOURCES THAT EXCEED DSHW REPORTING LEVEL FOR TREATMENT OF GB — ALL COPCs				
Exposure Scenario	**Receptor Location**	**Source**	**Hazard Index**	
			Adult	**Child**
Subsistence Rancher	32	BRA	0.23	0.43
		DFS	230	410
		LIC 1	130	240
		MPF	570	1,000
		LIC 2	280	500
		Total Non-Carcinogenic Hazard	**1,200**	**2,200**
Resident	32	BRA	0.042	0.14
		Total Non-Carcinogenic Hazard	**0.063**	**0.17**
On-Site Worker	13	BRA	0.070	NE
		Total Non-Carcinogenic Hazard	**0.071**	**NE**
Rush Lake Recreationist	NA	BRA	160	110
		DFS	0.05	0.03
		LIC 1	4.3	2.8
		MPF	0.050	0.031
		LIC 2	4.3	2.8
		Total Non-Carcinogenic Hazard	**170**	**110**
Rainbow Reservoir Fisher	NA	BRA	92	60
		DFS	0.025	<0.025
		LIC 1	1.9	1.2
		MPF	<0.025	<0.025
		LIC 2	1.9	1.2
		Total Non-Carcinogenic Hazard	**96**	**62**

Notes:

BRA	Brine reduction area
COPC	Compound of potential concern
DFS	Deactivation furnace system
DSHW	Utah Department of Environmental Quality Division of Solid and Hazardous Waste
GB	Isopropyl methylphosphonofluoridate
LIC	Liquid incinerator
MPF	Metal parts furnace
NA	Not applicable for water bodies. See text for discussion.
NE	Not evaluated for on-site worker scenario.
TOCDF	Tooele Chemical Agent Disposal Facility

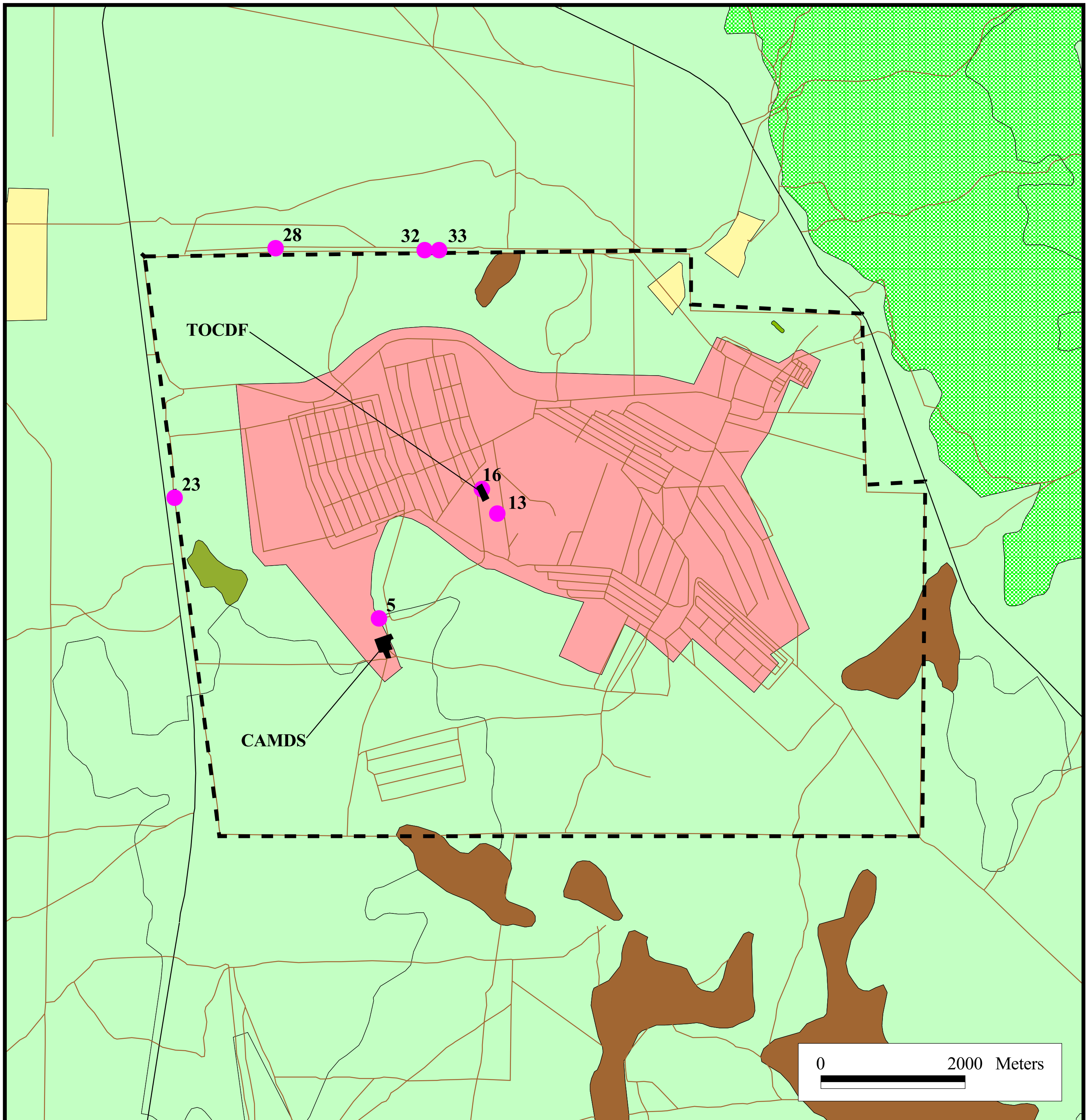
For the on-site worker scenario, the cancer risk value for the TOCDF MPF exceeds the DSHW reporting level, but is less than the EPA target level. Total cancer risk for the on-site worker, 3E-06, slightly exceeds the DSHW reporting level. The cancer risk that exceeds the DSHW reporting level is attributed to EMS. The highest cancer risk is associated with receptor location 16 (Figure 4-1). In terms of non-carcinogenic hazard, only the TOCDF BRA presents an HI value (0.070) above the DSHW reporting level for hazard but below the U.S. EPA target level. The hazard that exceeds the DSHW reporting level is attributed to total mercury (modeled as mercuric chloride). The HI value for the sum of all TOCDF sources is 0.071. The highest hazard was associated with receptor location 13 (Figure 4-1). The IRAP-*h* View output file for the on-site worker scenario is presented in Appendix F-3.

The risk and hazard associated with incidental ingestion of water was evaluated for an adult and child water skier at the SunTen water ski ponds. The results (Appendix F-4) indicate cumulative risks and hazards are less than DSHW reporting levels.

The adult and child recreationist scenario was evaluated to assess potential future exposures associated with ingestion of fish caught from Rush Lake and incidental ingestion of water from the lake. No sources at TOCDF present cancer risk that exceeds the DSHW reporting level. However, total cancer risk (addition of source-specific risks) exceeds the DSHW reporting level. In terms of hazard for the adult and child recreationist scenario, all TOCDF sources present HI values that exceed the DSHW reporting level (Table 4-2). The HI values for the BRA, LIC 1, LIC 2 exceed the U.S. EPA target HI level for both the adult and child recreationist. Approximately 97 percent of the HI values for the adult and child recreationists are due to emissions from the BRA. These hazards are associated with total mercury, modeled as methyl mercury, through the fish ingestion pathway. Hazard was modeled using the concentration of the COPC in water and sediment for the receptor location nearest to Rush Lake. The recreationist scenario was evaluated for a hypothetical person that may fish at Rush Lake, regardless of where the person resides. As such, no number is assigned to the receptor location that corresponds to the maximum off-site impact. The IRAP-*h* View output file for the recreationist scenario is presented in Appendix F-5.

Ingestion of fish that might be caught at Rainbow Reservoir was evaluated to assess potential future exposures to people who may fish at this water body. The results of this evaluation were similar to the Rush Lake fish ingestion pathway evaluated for the fisher adult and child exposure scenarios. The HI values for the BRA, LIC 1, and LIC 2 exceed the DSHW reporting level and the U.S. EPA target level for the adult and child fisher exposure scenarios. Similar to Rush Lake discussed above, the fisher scenario was evaluated for a hypothetical person that fishes at Rainbow Reservoir, so a receptor location that corresponds to the maximum impact was not identified. The IRAP-*h* View output file for the adult and child fisher scenario for Rainbow Reservoir is presented in Appendix F-6.

The magnitude of the hazard associated with fishing at Rainbow Reservoir is lower than for Rush Lake. Although Rush Lake is larger than Rainbow Reservoir, it dries down each year. The average volumetric flow rate (annual rate at which water moves through a water body) for Rush Lake was set equal to zero to correspond with the dry down to ensure that the potential for adverse health effects was not underestimated. The resulting total (water plus sediment) concentration of COPCs in a water body corresponds to the mass of COPC loading to the water body (no output of mass). Therefore, the elevated concentration of methyl mercury in fish for Rush Lake corresponds to the total concentration of COPCs for Rush Lake.



LEGEND

LANDUSE CLASSIFICATION

- AGRICULTURAL
- BARREN LAND
- FOREST LAND
- URBAN OR BUILT-UP LAND
- SHRUB/GRASS LAND
- WETLAND

- DESERET CHEMICAL DEPOT BOUNDARY
- 5 RECEPTOR LOCATION

N
W E
S

NOTES:
CAMDS = CHEMICAL AGENT MUNITIONS DISPOSAL SYSTEM
TOCDF = TOOELE CHEMICAL AGENT DISPOSAL FACILITY

SOURCES: U.S. ENVIRONMENTAL PROTECTION AGENCY, 1977, AND THE STATE OF UTAH DIVISION OF INFORMATION TECHNOLOGY SERVICES AUTOMATED GEOGRAPHIC REFERENCE CENTER, JULY 2000.

UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY
DIVISION OF SOLID AND HAZARDOUS WASTE

FIGURE 4-1
RECEPTOR LOCATIONS WITH MAXIMUM RISK OR HAZARD

TETRA TECH EM INC.

4.1.1.2 VX Campaign

The cancer risk associated with treatment of VX munitions at one or more TOCDF sources exceeds the DSHW reporting level of 1E-06 for the adult and child subsistence rancher scenarios and the adult and child resident scenarios. The maximum source-specific risks, and the corresponding receptor locations, for these scenarios are listed in Table 4-3. The HI values for one or more TOCDF sources exceed the DSHW reporting level of 0.025 for the adult and child subsistence rancher scenarios, the adult and child resident scenarios, the on-site worker scenario, the adult and child recreationist scenarios, and the adult and child fisher scenarios. The maximum source-specific HI values and the corresponding receptor locations for these scenarios are listed in Table 4-4. Source-specific risk and hazard values for several scenarios also exceed U.S. EPA target levels of 1E-05 for risk and 0.25 for hazard.

Emissions from the TOCDF DFS present the highest cancer risk (7E-05 for the adult) and the highest HI (1,400 for the child) for the adult and child subsistence rancher scenarios. Risks and hazards associated with emissions from other sources at TOCDF exhibited similar patterns (Tables 4-3 and 4-4). All sources except the HVAC (evaluated for hazard only) present risk and hazard that exceed DSHW reporting levels; several sources present risk and hazard that exceed U.S. EPA target levels of 1E-05 and an HI of 0.25. Similar to the evaluation of emissions from the GB campaign, excess cancer risks are attributable to PAHs and EMS. Similarly, DNOP presents more than 99 percent of the hazards. The maximum cancer risk values correspond to receptor location 32, and the maximum HI values correspond to receptor location 33 (Figure 4-1). The IRAP-*h* View output file for the adult and child subsistence rancher scenarios for the VX campaign is presented in Appendix G-1.

For the adult and child resident scenarios, the total cancer risk and HI values exceed the DSHW reporting levels but are less than the corresponding U.S. EPA target levels. Emissions from the MPF at TOCDF present the highest risk values for the adult (2E-06) and child (1E-06) resident scenarios. The risk value for the resident adult for the TOCDF DFS is about equal to the DSHW reporting level. The calculated risk values for EMS indicate this COPC is responsible for the risks associated with the MPF and DFS. Only the TOCDF BRA HI value of 0.047, calculated for the resident child scenario, exceeds the DSHW reporting level for hazard. The total mercury (modeled as mercuric chloride) HQ value of 0.042 for this scenario indicates that this COPC is responsible for most of the hazard. The maximum cancer risk and HI values are associated with receptor location 32 (Figure 4-1). The IRAP-*h* View output file for the adult and child resident scenarios for the VX campaign is presented in Appendix G-2.

The risk and hazard associated with incidental ingestion of water were evaluated for hypothetical adult and child water skiers at the SunTen water ski ponds. The results (Appendix G-4) indicate cumulative risks and hazards associated with the VX campaign are less than DSHW reporting levels.

None of the cancer risk values calculated for the adult and child recreationist scenarios exceed the DSHW reporting level. However, the HI values for both scenarios calculated for the TOCDF BRA and DFS units exceed the DSHW hazard reporting level of 0.025. The HI values for the BRA also exceed the U.S. EPA hazard target level of 0.25. The HI values for these sources and the total HI values are listed in Table 4-4. More than 99 percent of the calculated hazards are attributed to total mercury (modeled as methyl mercury) associated with ingestion of fish caught from Rush Lake, which was evaluated as a potential future pathway. The IRAP-*h* View output file for the recreationist adult and child scenarios for the VX campaign is presented in Appendix G-5.

TABLE 4-3 CANCER RISKS FOR TOCDF SOURCES THAT EXCEED DSHW REPORTING LEVEL FOR TREATMENT OF VX — ALL CO				
Exposure Scenario	**Receptor Location**	**Source**	**Cancer Risk**	
			Adult	**Child**
Subsistence Rancher	32	DFS	7E-05	2E-05
		LIC 1	4E-05	1E-05
		MPF	1E-05	6E-06
		LIC 2	4E-05	1E-05
		Total Cancer Risk	**2E-04**	**5E-05**
Resident	32	DFS	1E-06	<1E-06
		MPF	2E-06	1E-06
		Total Cancer Risk	**5E-06**	**3E-06**

Notes:

COPC	Compound of potential concern
DFS	Deactivation furnace system
DSHW	Utah Department of Environmental Quality Division of Solid and Hazardous Waste
LIC	Liquid incinerator
MPF	Metal parts furnace
TOCDF	Tooele Chemical Agent Disposal Facility
VX	O-ethyl-S-[2-diisopropylaminoethyl] methylphosphonthiolate

TABLE 4-4 HAZARD INDICES FOR TOCDF SOURCES THAT EXCEED DSHW REPORTING LEVEL FOR TREATMENT OF VX — ALL COPCs				
Exposure Scenario	**Receptor Location**	**Source**	**Hazard Index**	
			Adult	**Child**
Subsistence Rancher	33	BRA	0.06	0.11
		LIC1	13	24
		MPF	12	22
		LIC2	13	24
		DFS	770	1,400
		Total Non-Carcinogenic Hazard	**800**	**1,500**
Resident	32	BRA	<0.025	0.047
		Total Non-Carcinogenic Hazard	**<0.025**	**0.059**
Rush Lake Recreationist	NA	BRA	110	74
		DFS	0.13	0.082
		Total Non-Carcinogenic Hazard	**110**	**74**
Rainbow Reservoir Fisher	NA	BRA	38	25
		DFS	0.037	<0.025
		Total Non-Carcinogenic Hazard	**38**	**25**

Notes:

BRA	Brine reduction area
COPC	Compound of potential concern
DFS	Deactivation furnace system
DSHW	Utah Department of Environmental Quality Division of Solid and Hazardous Waste
LIC	Liquid incinerator
MPF	Metal parts furnace
NA	Not applicable for water bodies. See text for discussion.
TOCDF	Tooele Chemical Agent Disposal Facility
VX	O-ethyl-S-[2-diisopropylaminoethyl] methylphosphonothiolate

All cancer risk values and HI values for the on-site worker scenario for sources at TOCDF are less than the DSHW reporting levels. The IRAP-*h* View output file for the on-site worker scenario for the VX campaign is presented in Appendix G-3.

Ingestion of fish caught at Rainbow Reservoir was evaluated to assess potential future exposures to people who may fish at this water body. The results of this evaluation are similar to the fisher adult and child scenarios for the GB campaign. The fisher adult HI values for the BRA and DFS, and the fisher child HI value for the BRA, exceed the DSHW reporting levels. In addition, both HI values for the BRA exceed the U.S. EPA target level. The IRAP-*h* View output file for the fisher adult and child scenarios for Rainbow Reservoir for the VX campaign is presented in Appendix G-6.

The differences between the HI values associated with fishing at Rainbow Reservoir and at Rush Lake occurred because the average volumetric flow rate for Rush Lake was set equal to zero, as discussed in Section 4.1.1.2.

4.1.1.3 Sulfur Mustard Campaign

The cancer risk associated with treatment of sulfur mustard munitions at one or more TOCDF sources exceeds the DSHW reporting level of 1E-06 for the subsistence rancher adult and child scenarios and the adult and child resident scenarios. The maximum source-specific risks and the corresponding receptor locations for these scenarios are listed in Table 4-5. HI values associated with treatment of VX munitions at one or more TOCDF sources exceeds the DSHW hazard reporting level of 0.025 for the subsistence rancher adult and child scenarios, the adult and child resident scenarios, the on-site worker scenario, the adult and child recreationist scenarios, and the fisher adult and child scenarios. The maximum source-specific HI values and the corresponding receptor locations for these scenarios are listed in Table 4-6. Source-specific risk and hazard values for several scenarios also exceeded U.S. EPA target levels of 1E-05 for risk and 0.25 for hazard.

For the subsistence rancher adult and child scenarios, emissions from the DFS, LIC 1, MPF, and LIC 2 units at TOCDF present cancer risks and HI values that exceed the DSHW reporting levels and the U.S. EPA target levels (Tables 4-5 and 4-6). Maximum risks were associated with the DFS — 2E-04 for the subsistence rancher adult and 5E-05 for the subsistence rancher child. The DFS also presented the maximum HI values — 650 for the subsistence rancher adult and 1,200 for the subsistence rancher child. Similar to the results of the evaluation of these scenarios for the GB and VX campaigns, the elevated cancer risks are a result of risk from PAHs and EMS, and the elevated hazards are attributed mainly to DNOP, which accounted for more than 99 percent of the hazard. In addition, hazards posed by total mercury (modeled as mercuric chloride) and 2,4-dinitrophenol for the subsistence rancher adult and child scenarios exceed the DSHW reporting level, and hazard posed by mustard for the subsistence rancher child scenario exceeds the DSHW reporting level. However, the HI values for these three COPCs are small compared with the values for DNOP. The maximum cancer risk values correspond to receptor location 32, and the maximum HI values correspond to receptor location 33. The IRAP-*h* View output file for the subsistence rancher adult and child scenarios for the sulfur mustard campaign is presented in Appendix H-1.

TABLE 4-5 CANCER RISKS FOR TOCDF SOURCES THAT EXCEED DSHW REPORTING LEVEL FOR TREATMENT OF SULFUR MUSTARD — ALL COPCs				
Exposure Scenario	**Receptor Location**	**Source**	**Cancer Risk**	
			Adult	**Child**
Subsistence Rancher	32	DFS	2E-04	5E-05
		LIC 1	4E-05	1E-05
		MPF	6E-05	2E-05
		LIC 2	4E-05	1E-05
		Total Cancer Risk	**3E-04**	**9E-05**
Resident	32	DFS	3E-06	2E-06
		Total Cancer Risk	**5E-06**	**3E-06**
On-Site Worker	16	No source with risk > 1E-06	– –	NE
		Total Cancer Risk	**1E-06**	**NE**
Rush Lake Recreationist	NA	DFS	1E-06	<1E-06
		Total Cancer Risk	**2E-06**	**<1E-06**

Notes:

COPC Compound of potential concern
DFS Deactivation furnace system
DSHW Utah Department of Environmental Quality Division of Solid and Hazardous Waste
LIC Liquid incinerator
MPF Metal parts furnace
NA Not applicable for water bodies. See text for discussion.
NE Not evaluated for on-site worker scenario.
TOCDF Tooele Chemical Agent Disposal Facility

For the evaluation of the adult and child resident scenarios, emissions from the DFS at TOCDF present cancer risks that exceed the DSHW reporting level (Table 4-5). Emissions from the BRA and MPF at TOCDF present HI values for the child resident scenario that exceed the DSHW reporting level (Table 4-6). However, the risks and HI values calculated for these exposure scenarios are less than the U.S. EPA target levels. The cancer risk values for the DFS are attributed to elevated risk values for EMS, and the HI values for the BRA and MPF are explained by mercuric chloride (for the BRA) and mustard (for the MPF). The maximum cancer risk and HI values for each source are associated with receptor location 32 (Figure 4-1). The IRAP-*h* View output file for the adult and child resident scenarios for the sulfur mustard campaign is presented in Appendix H-2.

For the on-site worker scenario, the maximum cancer risk and HI values for the sulfur mustard campaign correspond with receptor location 16. Only the calculated HI value for the MPF (0.063) exceeds the DSHW reporting level for this location. However, this HI is less than the U.S. EPA target level. An elevated HQ of 0.63 for sulfur mustard accounts for the elevated HI for the MPF. The total cancer risk value for this receptor location (rounded to 1E-06) is slightly greater than the DSHW reporting level. The IRAP-*h* View output file for the on-site worker scenario for the sulfur mustard campaign is presented in Appendix H-3.

The risk and hazard associated with incidental ingestion of water was evaluated for hypothetical adult and child water skiers at the SunTen water ski ponds. The results (Appendix H-4) indicate that the total risk and HI values for the sulfur mustard campaign are less than DSHW reporting levels.

TABLE 4-6 HAZARD INDICES FOR TOCDF SOURCES THAT EXCEED DSHW REPORTING LEVEL FOR TREATMENT OF SULFUR MUSTARD — ALL COPCs				
Exposure Scenario	**Receptor Location**	**Source**	**Hazard Index**	
			Adult	**Child**
Subsistence Rancher	33	BRA	0.067	0.12
		DFS	650	1,200
		LIC 1	20	36
		MPF	200	360
		LIC 2	20	36
		Total Non-Carcinogenic Hazard	**890**	**1,600**
Resident	32	BRA	<0.025	0.057
		MPF	<0.025	0.046
		DFS	<0.025	0.033
		Total Non-Carcinogenic Hazard	**0.050**	**0.17**
On-Site Worker	16	MPF	0.063	NE
		Total Non-Carcinogenic Hazard	**0.11**	**NE**
Rush Lake Recreationist	NA	BRA	123	80
		DFS	0.043	0.028
		LIC 1	0.10	0.066
		MPF	1.7	1.1
		LIC 2	0.10	0.066
		Total Non-Carcinogenic Hazard	**130**	**81**
Rainbow Reservoir Fisher	NA	BRA	44	29
		LIC 1	0.028	<0.025
		MPF	0.48	0.31
		LIC 2	0.028	<0.025
		Total Non-Carcinogenic Hazard	**45**	**29**

Notes:

BRA	Brine reduction area
COPC	Compound of potential concern
DFS	Deactivation furnace system
DSHW	Utah Department of Environmental Quality Division of Solid and Hazardous Waste
LIC	Liquid incinerator
MPF	Metal parts furnace
NA	Not applicable for water bodies. See text for discussion.
NE	Not evaluated for on-site worker scenario.
TOCDF	Tooele Chemical Agent Disposal Facility

For the adult and child recreationist scenarios, the cancer risk value for the DFS exceeds the DSHW reporting level. In terms of hazard, the HI values for both scenarios calculated for each source at TOCDF exceed the DSHW hazard reporting level of 0.025. The HI values for the BRA, the LIC 1, the MPF, and LIC 2 calculated for the fisher adult scenario also exceed the U.S. EPA hazard target level of 0.25. In addition, the HI values for the BRA and the MPF calculated for the fisher child scenario exceed the U.S. EPA hazard target level. Similar to the results for the GB and VX campaigns, the elevated HQ values for methyl mercury for the fish ingestion pathway represent all the source-specific hazards. The IRAP-*h*

View output file for the adult and child recreationist scenarios for the sulfur mustard campaign is presented in Appendix H-5.

For the evaluation of the Rainbow Reservoir fisher adult and child scenarios, no source presents risk above the DSHW reporting level. The HI values for the fisher adult for the BRA, the LIC 1, the MPF, and the LIC 2 units, and the HI values for the fisher child for the BRA and the MPF, exceed the DSHW reporting level. In addition, HI values for the BRA and the MPF for both the fisher adult and fisher child exceed the U.S. EPA target level. The IRAP-*h* View output file for the adult and child fisher scenario for Rainbow Reservoir for the sulfur mustard campaign is presented in Appendix H-6.

As discussed in Section 4.1.1.2, the differences between the magnitude of HI values associated with fishing at Rainbow Reservoir and Rush Lake are explained by the average volumetric flow rate for Rush Lake, which was set equal to zero.

4.1.2 TOCDF Risks and Hazards from Detected COPCs Only

As described in Section 4.1.1, most of the COPCs that present risk or hazard for one of the evaluated exposure scenarios were evaluated as non-detected compounds with emission rates calculated from the analytical detection limit in the stack gas. To determine lower bound risks and hazards, similar analyses were performed for detected COPCs only. The risks and hazards posed by detected COPCs in emissions from the treatment of each agent are summarized in Tables 4-7 through 4-9. The receptor locations that correspond to the maximum risk and hazard values are also listed.

The IRAP-*h* View output files used for the analyses on the detected COPCs are the same as those used in the “all COPCs” analyses described in Sections 4.1.1.1 through 4.1.1.3. The Microsoft Access database in Appendix A was queried for risk and hazard values of detected COPCs only. Reports on risk and hazards for each exposure scenario for each agent campaign were generated in *.pdf format.

4.1.2.1 GB Campaign

For the GB campaign, source-specific cancer risk values for all exposure scenarios are less than the DSHW reporting level, indicating that cancer risk associated with emissions from the GB campaign is based on non-detected COPCs evaluated at the analytical detection limit in stack gas. In regard to non-carcinogenic hazard, total HI values based on detected COPCs only for the adult and child recreationist scenarios and the fisher adult and child scenarios exceed the DSHW reporting level (Table 4-7). These values are based on elevated HQs for total mercury (modeled as methyl mercury), indicating that, in several instances, elevated HI values calculated for “all COPCs” were based on non-detected total mercury. For example, the BRA HI values for “all COPCs” for the recreationist adult and child scenarios exceed 100 (Table 4-2). In contrast, the “detected COPCs only” BRA HI value is less than the DSHW reporting level of 0.025 (see Table 4-7; no value is listed for the BRA because the HI values are less than 0.025). In addition, a comparison of the source-specific HI values based on data for detected mercury (Table 4-7) with the corresponding values in Table 4-2 indicates the methyl mercury hazards for the DFS, MPF, LIC 1, and LIC 2 units are based on total mercury detected in stack gas samples.

Table 4-7 also lists the source-specific HI values for the fisher adult and child scenarios that exceed the DSHW reporting level. The magnitude of the fisher HI values based on only detected COPCs is substantially lower than the values calculated for all COPCs, indicating that the preponderance of hazard to the fisher for the GB campaign is due to non-detected COPCs.

TABLE 4-7 HAZARD INDICES FOR TOCDF SOURCES THAT EXCEED DSHW REPORTING LEVEL FOR TREATMENT OF GB — DETECTED COPCs ONLY				
Exposure Scenario	**Receptor Location**	**Source**	**Hazard Index**	
			Adult	**Child**
Rush Lake Recreationist	NA	DFS	0.051	0.033
		LIC 1	4.3	2.8
		MPF	0.049	0.031
		LIC 2	4.3	2.8
		Total Non-Carcinogenic Hazard	**8.7**	**5.6**
Rainbow Reservoir Fisher	NA	LIC 1	1.9	1.2
		LIC 2	1.9	1.2
		Total Non-Carcinogenic Hazard	**3.8**	**2.4**

Notes:

COPC Compound of potential concern
DFS Deactivation furnace system
DSHW Utah Department of Environmental Quality Division of Solid and Hazardous Waste
LIC Liquid incinerator
MPF Metal parts furnace
NA Not applicable for water bodies. See text for discussion.
TOCDF Tooele Chemical Agent Disposal Facility

TABLE 4-8 HAZARD INDICES FOR TOCDF SOURCES THAT EXCEED DSHW REPORTING LEVEL FOR TREATMENT OF VX — DETECTED COPCs ONLY				
Exposure Scenario	**Receptor Location**	**Source**	**Hazard Index**	
			Adult	**Child**
Subsistence Rancher	33	DFS	770	1,400
		Total Non-Carcinogenic Hazard	**770**	**1,400**
Rush Lake Recreationist	NA	DFS	0.13	0.082
		Total Non-Carcinogenic Hazard	**0.13**	**0.086**
Rainbow Reservoir Fisher	NA	DFS	0.037	0.025
		Total Non-Carcinogenic Hazard	**0.039**	**0.025**

Notes:

COPC Compound of potential concern
DFS Deactivation furnace system
DSHW Utah Department of Environmental Quality Division of Solid and Hazardous Waste
NA Not applicable for water bodies. See text for discussion.
TOCDF Tooele Chemical Agent Disposal Facility

TABLE 4-9 HAZARD INDICES FOR TOCDF SOURCES THAT EXCEED DSHW REPORTING LEVEL FOR TREATMENT OF SULFUR MUSTARD — DETECTED COPCs ONLY				
Exposure Scenario	**Receptor Location**	**Source**	**Hazard Index**	
			Adult	**Child**
Rush Lake Recreationist	NA	DFS	0.043	0.028
		LIC 1	0.10	0.066
		LIC 2	0.10	0.066
		Total Non-Carcinogenic Hazard	**0.25**	**0.16**
Rainbow Reservoir Fisher	NA	LIC 1	0.028	<0.025
		LIC 2	0.028	<0.025
		Total Non-Carcinogenic Hazard	**0.070**	**0.05**

Notes:

COPC Compound of potential concern
DFS Deactivation furnace system
DSHW Utah Department of Environmental Quality Division of Solid and Hazardous Waste
LIC Liquid incinerator
NA Not applicable for water bodies. See text for discussion.
TOCDF Tooele Chemical Agent Disposal Facility

The Microsoft Access reports for each exposure scenario discussed above are presented in Appendices I-1 through I-6.

4.1.2.2 VX Campaign

All source-specific cancer risk values for the VX campaign are less than the DSHW reporting level for cancer risk, indicating that cancer risk associated with emissions from treatment of VX munitions is based on non-detected COPCs evaluated at the analytical detection limit in stack gas. The total HI values for the rancher adult and child scenarios, the adult and child recreationist scenarios, and the fisher adult and child scenarios exceed the DSHW reporting level for hazard (Table 4-8). The HI values for the subsistence rancher adult and child scenarios at the DFS exceed the DSHW reporting level and the U.S. EPA target level for hazard. Comparison of these HI values to the values in Table 4-4, which were calculated based on all COPCs, indicates that (1) the hazard associated with the DFS is due to detected COPCs (mainly DNOP), and (2) the hazards associated with the BRA, the MPF, the LIC 1, and the LIC 2 are due to non-detected COPCs. The HI values in Table 4-8 for the adult and child recreationist scenarios indicate that (1) hazard associated with the DFS is due to detected COPCs, principally total mercury evaluated as methyl mercury, and (2) hazard associated with other sources at TOCDF is due to non-detected COPCs. Similar results hold true for the fisher adult and child scenarios.

The Microsoft Access reports for each exposure scenario discussed above are presented in Appendices J-1 through J-6.

4.1.2.3 Sulfur Mustard Campaign

All source-specific cancer risk values for the sulfur mustard campaign are less than the DSHW reporting level for cancer risk, indicating that cancer risk associated with emissions from the treatment of sulfur mustard munitions is based on non-detected COPCs. The total HI values for the adult and child recreationist scenarios and the fisher adult and child scenarios exceed the DSHW reporting level (Table 4-9). The HI values for the adult and child recreationist scenarios indicate (1) hazards associated with the DFS, LIC 1, and LIC 2 units are posed by detected COPCs (principally total mercury evaluated as methyl mercury), and (2) hazards associated with other sources at TOCDF are due to non-detected COPCs. Similar results hold true for the fisher adult and child scenarios.

The Microsoft Access reports for each exposure scenario discussed above are presented in Appendices K-1 through K-6.

4.1.3 CAMDS Risks and Hazards

The risk assessment for the CAMDS sources was performed using one set of worst-case, source-specific emission rates, as discussed in Section 3.3.4. The source-specific emission rate for each COPC was identified as the highest emission rate among those estimated for each agent campaign. These emission rates do not distinguish between detected and non-detected COPCs. Risks and hazards for each exposure scenario were calculated by summing source-specific risks and hazards based on the receptor location with the highest total cancer risk value and the receptor location with the highest total HI value. Presented below are the source-specific risks and hazards for the subsistence rancher adult and child scenarios, the adult and child resident scenarios, the on-site worker scenario, the adult and child recreationist scenarios, and the fisher adult and child scenarios. Risk values and HI values exceeding DSHW reporting levels are presented in Tables 4-10 and 4-11, respectively.

4.1.3.1 Subsistence Rancher Adult and Child Scenarios

The highest risks and hazards for the subsistence rancher adult and child scenarios correspond to receptor location 23, which is northwest of CAMDS along the western boundary of DCD. Total risks of 5E-04 for the subsistence rancher adult scenario and 1E-04 for the subsistence rancher child scenario were calculated. The DFS presents risks of 3E-04 and 9E-05 for the adult and child scenarios, respectively. The MPF presents risks of 2E-04 and 5E-05 for the adult and child scenarios, respectively. Individual COPCs with risk values that exceed the DSHW reporting level include EMS and three PAHs: dibenz(a,h)anthracene, benzo(a)pyrene, and indeno(1,2,3-cd)pyrene. In addition, EMS, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene also present risks that exceed the U.S. EPA target level.

In terms of hazard, total HI values of 1,700 for the adult scenario and 3,100 for the child scenario were calculated. The DFS presents HI values of 1,100 and 2,000 for the subsistence rancher adult and subsistence rancher child scenarios, respectively. The MPF presents HI values of 630 and 1,100 for the subsistence rancher adult and subsistence rancher child scenarios, respectively. HQ values for both 2,4-dinitrophenol and DNOP exceed the DSHW reporting level. However, more than 99 percent of the hazard is due to DNOP. The IRAP-*h* View output file for the analysis of risks and hazards for the subsistence rancher adult and child scenarios is presented in Appendix L-1.

4.1.3.2 Adult and Child Resident Scenarios

Highest risks and hazards for the adult and child resident scenarios also correspond to receptor location 23. Total risks of 7E-06 for the adult scenario and 5E-06 for the child scenario were calculated. The DFS presents risks of 4E-06 and 3E-06 for the adult and child scenarios, respectively. The MPF presents risk 2E-06 for both scenarios. The DFS and MPF EMS risk values for both scenarios exceed the DSHW reporting level, but not the U.S. EPA target level.

In terms of hazard, total HI values of 0.029 for the resident adult scenario and 0.070 for the resident child scenario were calculated. The resident child HI values for the DFS and MPF exceed the DSHW reporting level but are less than the U.S. EPA target level. Unit-specific HI values for the resident adult scenario are less than the DSHW reporting level. All COPC HQ values were less than the DSHW reporting level for hazard. The IRAP-*h* View output file for the analysis of risks and hazards for the adult and child resident scenarios is presented in Appendix L-2.

TABLE 4-10
CANCER RISKS FOR CAMDS SOURCES THAT EXCEED THE DSHW REPORTING LEVEL

Exposure Scenario	Receptor Location	Source	Cancer Risk	
			Adult	Child
Subsistence Rancher	23	DFS	3E-04	9E-05
		MPF	2E-04	7E-05
		Total Cancer Risk	**5E-04**	**1E-04**
Resident	23	DFS	4E-06	3E-06
		MPF	2E-06	2E-06
		Total Cancer Risk	**7E-06**	**5E-06**
On-Site Worker	5	DFS	3E-06	NE
		MPF	3E-06	NE
		Total Cancer Risk	**6E-06**	**NE**
Rush Lake Recreationist	NA	DFS	1E-06	<1E-06
		Total Cancer Risk	**2E-06**	**<1E-06**

Notes:

CAMDS Chemical Agent Munitions Disposal System
COPC Compound of potential concern
DFS Deactivation furnace system
DSHW Utah Department of Environmental Quality Division of Solid and Hazardous Waste
MPF Metal parts furnace
NA Not applicable for evaluation of water bodies. See text for discussion.
NE Not evaluated for on-site worker scenario.

4.1.3.3 On-Site Worker Scenario

The highest risks for the on-site worker scenario correspond to receptor location 5, which is on the north side of the CAMDS facility. The DFS and MPF units at CAMDS present risks above the DSHW reporting level of 1E-06, but below the U.S. EPA target level of 1E-05. Total risk was calculated at 6E-06. Two COPCs are mainly responsible for risk. For the DFS, EMS risk (1E-06) exceeds the DSHW reporting level. For the MPF, total chromium (modeled as hexavalent chromium) presents risk of 2E-06, which also exceeds the DSHW reporting level. In terms of hazard, a total HI value equal to 0.054 was calculated. The DFS and MPF present HI values of 0.029 and 0.025, respectively. No single COPC presents an HQ value that exceeds the DSHW reporting level of 0.025. The IRAP-*h* View output file for the analysis of CAMDS risks and hazards for the on-site worker scenario is presented in Appendix L-3.

4.1.3.4 SunTen Water Skier Scenario

The total risks and hazards for the incidental ingestion of water scenario for the SunTen water ski lakes are well below the DSHW reporting levels of 1E-06 for risk and 0.025 for hazard. The IRAP-*h* View output file for the analysis of risks and hazards for this scenario is presented in Appendix L-4.

4.1.3.5 Rush Lake Adult and Child Recreationist Scenarios

For the adult and child recreationist scenarios, total risk of 2E-06 was calculated for the adult scenario. The risk for the child scenario is less than the DSHW reporting level. The calculated risk of 1E-06 for the DFS (for the adult recreationist) exceeds the DSHW reporting level; however, no single COPC presents risk exceeding the reporting level. Risk for the MPF is less than the DSHW reporting level. In terms of hazard, total HI values of 3.4 for the adult recreationist scenario and 2.3 for the child recreationist scenario were calculated. The DFS and MPF present HI values for the adult scenario that exceed the DSHW reporting level of 0.025 as well as the U.S. EPA target level of 0.25. The DFS HI value for the child scenario exceeds the DSHW reporting level and equals the U.S. EPA target level. The MPF HI value for the child scenario exceeds both the reporting level and target level. Excess HI values are due to methyl mercury exposure through the fish ingestion pathway. The IRAP-*h* View output file for the analysis of risks and hazards for the adult and child recreationist scenarios is presented in Appendix L-5.

TABLE 4-11
HAZARD INDICES FOR CAMDS SOURCES EXCEEDING THE DSHW REPORTING LEVEL

Exposure Scenario	Receptor Location	Source	Hazard Index	
			Adult	**Child**
Subsistence Rancher	23	DFS	1,100	2,000
		MPF	630	1,100
		Total Non-Carcinogenic Hazard	**1,700**	**3,100**
Resident	23	DFS	<0.025	0.038
		MPF	<0.025	0.032
		Total Non-Carcinogenic Hazard	**0.029**	**0.070**
On-Site Worker	5	DFS	0.029	NE
		MPF	0.025	NE
		Total Non-Carcinogenic Hazard	**0.054**	**NE**
Rush Lake Recreationist	NA	DFS	0.38	0.25
		MPF	3.1	2.0
		Total Non-Carcinogenic Hazard	**3.5**	**2.3**
Rainbow Reservoir Fisher	NA	DFS	0.092	0.059
		MPF	0.74	0.48
		Total Non-Carcinogenic Hazard	**0.83**	**0.54**

Notes:

CAMDS	Chemical Agent Munitions Disposal System
DFS	Deactivation furnace system
DSHW	Utah Department of Environmental Quality Division of Solid and Hazardous Waste
MPF	Metal parts furnace
NA	Not applicable for water bodies. See text for discussion.
NE	Not evaluated for on-site worker scenario.

4.1.3.6 Rainbow Reservoir Fisher Adult and Child Scenarios

For the evaluation of the Rainbow Reservoir fish ingestion pathway, no sources at CAMDS present risk greater than the DSHW reporting level. In terms of hazard, total HI values of 0.83 and 0.54 were calculated for the adult and child scenarios, respectively. The HI values for the DFS and MPF exceed the DSHW reporting level of 0.025 for both the adult and child fisher scenarios. In addition, the adult and child HI values for the MPF exceed the U.S. EPA target level of 0.25. The elevated HI values are due to methyl mercury exposure. The IRAP-*h* View output file for the analysis of risks and hazards for the fisher adult and child scenarios is presented in Appendix L-6.

4.1.4 Cumulative Risks and Hazards

Cumulative risks and hazards for each exposure scenario were evaluated to test a hypothetical situation in which all TOCDF sources and all CAMDS sources operate concurrently. As described in Section 3.3.4, sources at TOCDF were evaluated with source-specific, weighted average emission rates, and sources at CAMDS were evaluated with worst-case, source-specific emission rates. Each set of evaluations includes a single COPC emission rate for each source at TOCDF and CAMDS. For each TOCDF source, agent-specific emission rates were first weighted in proportion to the duration of each agent campaign; average COPC emission rates were then calculated for each source. The emission rates for the sources at CAMDS were estimated as described in Section 4.1.3. The weighted-average emission rates and worst-case emission rates do not distinguish between detected and non-detected COPCs. Cumulative risks and hazards for each exposure scenario were calculated by summing source-specific risks and hazards based on the receptor location with the highest cumulative cancer risk and the receptor location with the highest cumulative hazard. Presented below are the source-specific cumulative risks and hazards for the subsistence rancher adult and child scenarios, the adult and child resident scenarios, the on-site worker scenario, the adult and child recreationist scenarios, and the fisher adult and child scenarios.

4.1.4.1 Subsistence Rancher Adult and Child Scenarios

Source-specific cumulative risks and hazards for the subsistence rancher adult and child scenarios are presented in Table 4-12. The highest risks and hazards correspond to receptor location 28. All sources except the HVAC systems at CAMDS and TOCDF present risk or HI values that exceed DSHW reporting levels. COPCs with risk or hazard that exceed DSHW reporting levels are also listed. Total cumulative risks of 7E-04 for the subsistence rancher adult and 2E-04 for subsistence rancher child scenarios were calculated. Elevated cancer risk values are a result of exposures to indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene. Total HI values of 2,400 for the subsistence rancher adult scenario and 4,400 for the subsistence rancher child scenario were calculated. The elevated HI values are the result of estimated DNOP emissions from the DFS for the VX campaign at TOCDF. These emissions were estimated from data from the CAMDS DFS VX test burn, which was carried out under operating conditions that differed from a trial burn. In addition, DNOP was not detected in DFS emissions at TOCDF based on the available GB trial burn data. This information suggests that the DNOP emissions from the DFS may be an artifact. The IRAP-*h* View output file for the analysis of cumulative risks and hazards for the subsistence rancher adult and child scenario is presented in Appendix L-1.

4.1.4.2 Adult and Child Resident Scenarios

Source-specific cumulative risks and hazards for the adult and child resident scenarios are presented in Table 4-13. The highest risks correspond to receptor location 28, while the highest hazards correspond to receptor location 32. The DFS and MPF units at both CAMDS and TOCDF present risk or HI values that exceed DSHW reporting levels. COPCs that exceed DSHW reporting levels are also listed. Total cumulative risks of 1E-05 for the adult resident scenario and 9E-06 for the child resident scenario were calculated. Total HI values of 0.11 for the adult resident scenario and 0.34 for the child resident scenario were calculated. The IRAP-*h* View output file for the analysis of cumulative risks and hazards for the adult and child resident scenarios is presented in Appendix L-2

4.1.4.3 On-Site Worker Scenario

Source-specific cumulative risks and hazards for the on-site worker scenario are presented in Table 4-14. The highest risks correspond to receptor location 5, while highest hazards correspond to receptor location 16. The DFS and MPF units at CAMDS pose risks above the DSHW reporting level of 1E-06, but below the U.S. EPA target level of 1E-05. Two COPCs are mainly responsible for risk. For the DFS at CAMDS, EMS (1E-06) exceeds the DSHW reporting level. For the MPF at CAMDS, total chromium risk of 6E-06 and a total HI of 0.14 were calculated. The IRAP-*h* View output file for the analysis of cumulative risks and hazards for the on-site worker scenarios is presented in Appendix L-3.

TABLE 4-12 CUMULATIVE CANCER RISKS AND HAZARD INDICES FOR SUBSISTENCE RANCHER ADULT AND CHILD SCENARIOS THAT EXCEED THE DSHW REPORTING LEVELS						
Source	Cumulative Cancer Risk (Receptor Location 28)			Cumulative Hazard Index (Receptor Location 28)		
	Adult	Child	COPC > DSHW RL [1]	Adult	Child	COPC > DSHW RL [1]
CAMDS DFS	3E-04	7E-05	EMS, B(a)P, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene	940	1,700	DNOP, 2,4-Dinitrophenol
CAMDS MPF	1E-04	3E-05	EMS, B(a)P, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene	480	870	DNOP, 2,4-Dinitrophenol (child only)
TOCDF BRA	<1E-06	<1E-06	NA	0.19	0.35	Mercuric chloride, methyl mercury (child only)
TOCDF DFS	9E-05	3E-05	EMS, B(a)P, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene	410	740	DNOP, 2,4-Dinitrophenol (child only)
TOCDF LIC 1	4E-05	1E-05	EMS, dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene	81	150	DNOP
TOCDF MPF	1E-04	3E-05	EMS, B(a)P, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene	360	650	DNOP, 2,4-Dinitrophenol (child only)
TOCDF LIC 2	6E-05	2E-05	EMS, B(a)P, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene	160	290	DNOP
Total Risk or Hazard	**7E-04**	**2E-04**		**2,400**	**4,400**	

Notes:

1 COPC with cancer risk value or hazard quotient that exceeded DSHW reporting level for cancer risk (1E-06) or hazard quotient (0.025).

B(a)P Benzo(a)pyrene
BRA Brine reduction area
CAMDS Chemical Agent Munitions Disposal Facility
COPC Compound of potential concern
DFS Deactivation furnace system
DNOP Di-n-octylphthalate
DSHW Utah Department of Environmental Quality Division of Solid and Hazardous Waste
EMS Ethyl methanesulfonate
LIC Liquid incinerator
MPF Metal parts furnace
NA Not applicable
RL Reporting level
TOCDF Tooele Chemical Agent Disposal Facility

4.1.4.4 SunTen Water Skier Scenario

The total cumulative risks and hazards for the incidental ingestion of water scenario for the Sun Ten water ski lakes are well below the DSHW reporting levels of 1E-06 for risk and 0.025 for hazard. The IRAP-*h* View output file for the analysis of cumulative risks and hazards for this scenario is presented in Appendix L-4.

4.1.4.5 Rush Lake Adult and Child Recreationist Scenarios

Source-specific cumulative hazards for the adult and child resident scenarios are presented in Table 4-15. No individual sources present risk greater than the DSHW reporting level. All sources except for the HVAC systems at CAMDS and TOCDF present HI values that exceed the DSHW reporting level of 0.025. Total cumulative risk of 4E-06 was calculated for the adult recreationist scenario. Total HI values of 230 for the adult and 150 for the child scenarios were calculated. The IRAP-*h* View output file for the analysis of cumulative risks and hazards for the adult and child recreationist scenarios is presented in Appendix L-5.

TABLE 4-13
CUMULATIVE CANCER RISKS AND HAZARD INDICES FOR ADULT AND CHILD RESIDENT SCENARIOS THAT EXCEED THE DSHW REPORTING LEVELS

Source	Cumulative Cancer Risk (Receptor Location 28)			Cumulative Hazard Index (Receptor Location 32)		
	Adult	Child	COPC [1]	Adult	Child	COPC [1]
CAMDS DFS	4E-06	7E-05	EMS	<0.025	<0.025	NA
CAMDS MPF	2E-06	3E-05	EMS	<0.025	<0.025	NA
TOCDF BRA	<1E-06	<1E-06	NA	0.069	0.22	Mercuric chloride
TOCDF DFS	2E-06	3E-05	EMS	<0.025	<0.025	NA
TOCDF MPF	3E-06	3E-05	EMS	<0.025	0.028	No single COPC exceeds DSHW reporting level
TOCDF HVAC	<1E-06	<1E-06	NA	<0.025	0.027	Sulfur mustard
Cumulative Risk Or Hazard	**1E-05**	**9E-06**	**NA**	**0.11**	**0.38**	**NA**

Notes:

1 COPC with cancer risk value or hazard quotient that exceeded DSHW reporting level for cancer risk (1E-06) or hazard quotient (0.025).

BRA Brine reduction area
CAMDS Chemical Agent Munitions Disposal Facility
COPC Compound of potential concern
DFS Deactivation furnace system
DSHW Utah Department of Environmental Quality Division of Solid and Hazardous Waste
EMS Ethyl methanesulfonate
HVAC Heating, ventilation, and air conditioning system
MPF Metal parts furnace
NA Not applicable
TOCDF Tooele Chemical Agent Disposal Facility

TABLE 4-14 CUMULATIVE CANCER RISKS AND HAZARD INDICES FOR ON-SITE WORKER SCENARIO THAT EXCEED THE DSHW REPORTING LEVELS						
Source	**Cumulative Cancer Risk**	**Receptor Location**	**COPC [1]**	**Cumulative HI**	**Receptor Location**	**COPC [1]**
CAMDS DFS	3E-06	5	EMS	<0.025	NA	NA
CAMDS MPF	3E-06	5	Total chromium, modeled as hexavalent chromium	<0.025	NA	NA
TOCDF DFS	<1E-06	NA	NA	0.027	16	No single COPC exceeds DSHW reporting level
TOCDF LIC 1	<1E-06	NA	NA	0.029	16	No single COPC exceeds DSHW reporting level
TOCDF MPF	<1E-06	NA	NA	0.065	16	Sulfur mustard
Total Risk or Hazard	**6E-06**	NA	NA	**0.14**	NA	NA

Notes:

1 COPC with cancer risk value or hazard quotient that exceeded DSHW reporting level for cancer risk (1E-06) or hazard quotient (0.025).

CAMDS Chemical Agent Munitions Disposal Facility
COPC Compound of potential concern
DFS Deactivation furnace system
DSHW Utah Department of Environmental Quality Division of Solid and Hazardous Waste
HI Hazard index
LIC Liquid incinerator
MPF Metal parts furnace
NA Not applicable
TOCDF Tooele Chemical Agent Disposal Facility

4.1.4.6 Rainbow Reservoir Fisher Adult and Child Scenarios

Source-specific cumulative hazards for the fisher adult and child scenarios are presented in Table 4-16. No individual sources present risk greater than the DSHW reporting level. All sources except for the HVAC systems at CAMDS and TOCDF present HI values that exceed the DSHW reporting level of 0.025. Total cumulative risk of 1E-06 was calculated for the adult fisher scenario. Risk for the child scenario is less than the DSHW reporting level. Total HI values of 150 for the adult and 98 for the child scenarios were calculated. The IRAP-*h* View output file for the analysis of cumulative risks and hazards for the fisher adult and child scenarios is presented in Appendix L-6.

TABLE 4-15 CUMULATIVE HAZARD INDICES FOR ADULT AND CHILD RECREATIONIST SCENARIOS THAT EXCEED THE DSHW REPORTING LEVEL			
Source	**Cumulative Hazard Index**		
	Adult	**Child**	**COPC [1]**
CAMDS DFS	0.38	0.24	Total mercury (modeled as methyl mercury)
CAMDS MPF	3.1	2.00	Total mercury (modeled as methyl mercury)
TOCDF BRA	220	140	Total mercury (modeled as methyl mercury)
TOCDF DFS	0.10	0.067	Total mercury (modeled as methyl mercury)
TOCDF LIC 1	3.4	2.2	Total mercury (modeled as methyl mercury)
TOCDF MPF	0.74	0.48	Total mercury (modeled as methyl mercury)
TOCDF LIC 2	3.37	2.2	Total mercury (modeled as methyl mercury)
Total Hazard	**230**	**150**	

Notes:

1 COPC with cancer risk or hazard value that exceeded DSHW reporting level for cancer risk (1E-06) or hazard quotient (0.025).

BRA Brine reduction area
CAMDS Chemical Agent Munitions Disposal Facility
COPC Compound of potential concern
DFS Deactivation furnace system
DSHW Utah Department of Environmental Quality Division of Solid and Hazardous Waste
LIC Liquid incinerator
MPF Metal parts furnace
TOCDF Tooele Chemical Agent Disposal Facility

4.1.5 Evaluation of Infant Breast Milk Pathway for Dioxins

Risk to nursing infants was evaluated by comparing the modeled intake rate for 2,3,7-8-TCDD TEQ in breast milk to the 6 picograms TEQ per kilogram body weight per day (pg/kg BW-d) reporting level established by DSHW. This value is 10 percent of the average background exposure level reported by U.S. EPA (1998). This analysis used the weighted-average emission rates for the sources at TOCDF and the worst-case emission rates for the sources at CAMDS, which assumes that all sources are operating concurrently. The analysis was completed for the subsistence rancher scenario, the resident scenario, and the on-site worker scenario.

The calculated intake rates for 2,3,7,8-TCDD TEQ for each source are less than the DSHW reporting level of 6 pg/kg BW-d for all scenarios evaluated, indicating dioxin emissions do not present a risk to a nursing infant. The intake rates for the subsistence rancher scenario ranged from 0.19 pg/kg BW-d for the DFS at TOCDF to 1.77 pg/kg BW-d for the DFS at CAMDS. The intake rates for the residential scenario ranged from 2E-05 pg/kg BW-d for the DFS at TOCDF to 7E-03 pg/kg BW-d for the MPF at CAMDS. The intake rates for the on-site worker scenario ranged from 6E-06 pg/kg BW-d for the DFS at TOCDF to 0.097 pg/kg BW-d for the MPF at CAMDS.

The IRAP-*h* View output files for the rancher, resident, and on-site worker scenarios are presented in Appendices M-1 through M-3.

TABLE 4-16 CUMULATIVE HAZARD INDICES FOR FISHER ADULT AND CHILD SCENARIOS THAT EXCEED THE DSHW REPORTING LEVEL			
Source	**Cumulative Hazard Index**		
	Adult	**Child**	**COPC [1]**
CAMDS DFS	0.09	0.059	Total mercury (modeled as methyl mercury)
CAMDS MPF	0.74	0.48	Total mercury (modeled as methyl mercury)
TOCDF BRA	150	95	Total mercury (modeled as methyl mercury)
TOCDF DFS	0.061	0.039	Total mercury (modeled as methyl mercury)
TOCDF LIC 1	1.8	1.1	Total mercury (modeled as methyl mercury)
TOCDF MPF	0.39	0.25	Total mercury (modeled as methyl mercury)
TOCDF LIC 2	1.8	1.1	Total mercury (modeled as methyl mercury)
Total Hazard	**150**	**98**	

Notes:

1 COPC with cancer risk or hazard value that exceeded DSHW reporting level for cancer risk (1E-06) or hazard quotient (0.025).

BRA Brine reduction area
CAMDS Chemical Agent Munitions Disposal Facility
COPC Compound of potential concern
DFS Deactivation furnace system
DSHW Utah Department of Environmental Quality Division of Solid and Hazardous Waste
LIC Liquid incinerator
MPF Metal parts furnace
TOCDF Tooele Chemical Agent Disposal Facility

4.1.6 Evaluation of Mutton and Goat's Milk Pathways for the Subsistence Rancher

Concentrations of COPCs in mutton and goat's milk were calculated and compared with concentrations of COPCs in beef and cow's milk to evaluate whether the beef ingestion pathway and cow's milk ingestion pathway are protective for the subsistence rancher adult and child who ingest farm-raised mutton and goat's milk. The agent-specific analysis was performed for the sources at TOCDF based on estimated concentrations of COPCs, which were summed for all sources to calculate the cumulative, or worst-case, concentrations. The comparison used concentrations of DNOP (a systemic non-carcinogenic toxicant) and acenaphthene (a carcinogen) because these bioaccumulative compounds can be present at significant concentrations in meat and milk. The analysis was completed for each agent. Concentrations of COPCs in poultry and pork, two other pathways for the subsistence rancher adult and child scenario, are also presented for comparison.

The agent-specific detected concentrations of COPCs in mutton, beef, chicken, and pork are presented in Table 4-17. The estimated concentrations of COPCs in beef cattle exceed those in mutton, indicating that the beef ingestion pathway is protective for a subsistence rancher who eats farm-raised mutton.

The agent-specific detected concentrations of COPCs in cow's and goat's milk are presented in Table 4-18. The estimated concentrations of COPCs in cow's milk exceed those in goat's milk, indicating that the cow's milk pathway is protective for a subsistence rancher who ingests farm-raised goat milk.

The IRAP-*h* View output files for COPC concentrations in meats and milks, specific to each agent campaign at TOCDF, are presented in Appendices N through P.

4.1.7 Evaluation of Acute Inhalation Hazards

Acute inhalation hazard was evaluated for the on-site worker and the adult and child resident scenarios. Each agent campaign was evaluated separately. The receptor locations that corresponded to the highest on-site cumulative HI value and the highest off-site cumulative HI value were identified. Off-site inhalation hazard was evaluated for the resident adult and child scenarios.

For the GB campaign, a maximum HI value of 0.014 was calculated for the on-site worker scenario, and a maximum HI value of 0.002 was calculated for both the adult resident and child resident scenarios. For the VX campaign, a maximum HI value of 0.015 was calculated for the on-site worker scenario, and a maximum HI value of 0.002 was calculated for both the adult resident and child resident scenarios. For the sulfur mustard campaign, a maximum HI value of 0.030, which exceeds the DSHW reporting level of 0.025, was calculated for the on-site worker scenario. However, the value is less than the U.S. EPA target level of 1. A maximum HI value of 0.003 was calculated for both the adult resident and child resident scenarios.
The weighted-average emission rates for the sources at TOCDF and the worst-case emission rates for the CAMDS sources were also evaluated to estimate cumulative acute inhalation hazards. For this evaluation, a maximum cumulative HI value of 0.041 was calculated for the on-site worker scenario, and a maximum cumulative HI value of 0.008 was calculated for the adult resident and child scenarios. The maximum cumulative HI value for the on-site worker scenario exceeds the DSHW reporting level but is less than the U.S. EPA target level.

The Microsoft Access project files for the evaluation of acute inhalation hazard are presented in Appendices Q-1 through Q-8.

TABLE 4-17
COMPARISON OF CONCENTRATIONS OF COPCs IN MUTTON, BEEF, POULTRY, AND PORK

Agent	Receptor Location	COPC	Maximum Concentration [1]			
			Mutton	Beef	Poultry	Pork
GB	32	DNOP	412	4,805	0.00012	405
		Acenaphthene	3E-09	2E-08	4E-08	1E-08
VX	32	DNOP	270	3,146	0.00008	265
		Acenaphthene	1E-09	9E-09	2E-10	5E-09
Sulfur Mustard	32	DNOP	302	3,516	0.00009	296
		Acenaphthene	3E-09	2E-08	3E-10	1E-08

Notes:

1 Tissue concentration reported as milligrams per kilogram fresh weight.

COPC Compound of potential concern
DNOP Di-n-octylphthalate
GB Isopropyl methylphosphonofluoridate
VX O-ethyl-S-[2-diisopropylaminoethyl] methylphosphonothiolate

TABLE 4-18 COMPARISON OF CONCENTRATIONS OF COPCs IN GOAT'S MILK AND COW'S MILK				
Agent	Receptor Location	COPC	Maximum Concentration [1]	
			Goat's Milk	Cow's Milk
GB	32	DNOP	285	2,306
		Acenaphthene	1E-09	1E-08
VX	32	DNOP	186	1,510
		Acenaphthene	5E-10	5E-09
Sulfur Mustard	32	DNOP	208	1,687
		Acenaphthene	1E-09	9E-09

Notes:

[1] Milk concentration reported as milligrams per kilogram fresh weight.

COPC Compound of potential concern
DNOP Di-n-octylphthalate
GB Isopropyl methylphosphonofluoridate
VX O-ethyl-S-[2-diisopropylaminoethyl] methylphosphonothiolate

4.1.8 Evaluation of Polychlorinated Biphenyls

PCBs were evaluated to calculate (1) the HI value for "total PCBs," and (2) the cancer risk for the coplanar, or dioxin-like, PCBs. Agent-specific analyses were completed for each source at TOCDF. Cumulative risk and hazard were also evaluated using the weighted-average emission rates for the sources at TOCDF and the worst-case emission rates for the sources at CAMDS. The results of the agent-specific analyses indicate that all source-specific total HI values for PCBs are less than the DSHW reporting level of 0.025. In addition, all source-specific cancer risk values for dioxin-like PCBs are less than the DSHW reporting level of 1E-06. These analyses were based on the "all COPCs" output discussed in Section 4.1.1. The query of this output also indicated that cumulative risk and hazard for total PCBs and dioxin-like PCBs are less than the DSHW reporting levels.

The PCB risk and hazard values are located in the data tables in the database in Appendix A. The PCB risk values are labeled "PCB TEQ" and the hazard values are labeled "Aroclor 1254."

4.1.9 Evaluation of Dioxins

Dioxin risk was evaluated for the subsistence rancher adult and child scenarios because these receptors would be expected to have the greatest potential for uptake of dioxins based on the preponderance of meats and dairy products in their diets. While risk for the resident scenario is usually about two orders of magnitude less than the risk for the subsistence rancher scenario, dioxin risk for the resident adult and child scenarios were also evaluated to check this assumption. The Microsoft Access reports for the subsistence rancher and resident scenarios are presented in Appendices R-1 and R-2.

For the GB and VX campaigns at TOCDF, no source presents dioxin risk that exceeds the DSHW reporting level. For the sulfur mustard campaign at TOCDF, dioxin risk slightly exceeds the DSHW reporting level for the subsistence rancher adult for the LIC 1 unit (1E-06) and LIC 2 unit (1E-06). Emissions for these two units were modeled based on two detected dioxin congeners: octachlorodibenzo(p)dioxin and octachlorodibenzofuran. For CAMDS, evaluation of the worst-case emissions indicates dioxin risk exceeds the DSHW reporting level for the subsistence rancher adult for the DFS (2E-06) and MPF units (2E-06). These risk values are based on non-detected dioxin congeners.

While these risk values exceed the DSHW reporting level, they are less than the U.S. EPA target level of 1E-05.

All dioxin risk values for the adult and child resident scenarios are less than the DSHW reporting level.

In 2000, the Science Advisory Board of the U.S. EPA proposed a new dioxin cancer slope factor of 1.0E+06 (mg/kg BW-day)$^{-1}$, which is 6.67 times more stringent than the current cancer slope factor. The proposed slope factor has not been adopted. Characterization of dioxin risk for the subsistence rancher adult and child scenarios based on the new proposed slope factor indicates the following exceedances:

- For the GB campaign at TOCDF, dioxin risk for the DFS, LIC 1, MPF, and LIC 2 would exceed the DSHW reporting level for the subsistence rancher adult scenario.

- For the VX campaign at TOCDF, dioxin risk for the LIC 1 and LIC 2 would exceed the DSHW reporting level for the subsistence rancher adult scenario.

- For the sulfur mustard campaign at TOCDF, dioxin risk for the DFS, LIC 1, and LIC 2 would exceed the DSHW reporting level for the subsistence rancher adult scenario, and the LIC 1 and LIC 2 would exceed the DSHW reporting level for the subsistence rancher child scenario.

- Based on weighted-average emission rates for the TOCDF units, dioxin risk for the DFS, LIC 1, MPF, and LIC 2 would exceed the DSHW reporting level for the subsistence rancher adult scenario.

Based on worst-case emission rates for the CAMDS incineration units, the DFS and MPF would present dioxin risk that (1) exceeds the U.S. EPA target level of 1E-05 for the subsistence rancher adult scenario, and (2) exceeds the DSHW reporting level of 1E-06 for the subsistence rancher child scenario.

4.1.10 Evaluation Of Lead

The maximum concentrations of lead in on-site and off-site soil were identified from the cumulative risk and hazard analyses described in Section 4.1.2. The calculated on-site concentration of 22.57 mg/kg and off-site concentration of 0.38 mg/mg are each well below the 400 mg/kg threshold identified by U.S. EPA, indicating that lead does not pose a hazard. In addition, the maximum concentration of lead in on-site air was estimated to be 0.009 μg/m^3 at receptor location 4, which is adjacent to the south side of the CAMDS facility. The maximum concentration of lead in off-site air was estimated to be 0.001 μg/m^3 at receptor location 44, which is on the northern boundary of DCD. These concentrations are well below the National Ambient Air Quality Standard of 1.5 μg/m^3.

The Microsoft Access project files for the soil and air concentrations are presented in Appendices S-1 and S-2, respectively.

4.1.11 Evaluation Of Risks And Hazards For Subsistence Rancher Who Works At DCD

The cumulative risk and hazard (described in Section 4.2) for the subsistence rancher adult and the on-site worker were evaluated to calculate the additional risk and hazard for a subsistence rancher who works at DCD. This evaluation is based on weighted-average emissions from units at TOCDF and worst-case emissions from units at CAMDS. Specifically, the risk was calculated as 7E-04 and the HI was calculated as 2,400 for the subsistence rancher adult. The risk was calculated as 6E-06 and the HI was calculated as 0.14 for the on-site worker. These results indicate that the additional risk and hazard associated with working at DCD are negligible.

4.2 UNCERTAINTY ANALYSIS

The uncertainty analysis was performed to (1) identify major uncertainties associated with the risk and hazard estimates, (2) evaluate the effect of the time period of combustion on the estimates of risk and hazard, and (3) evaluate the significance of COPCs that exceed DSHW reporting levels and U.S. EPA target levels.

4.2.1 Major Uncertainties

Major uncertainties associated with the risk estimates were identified for the three main parts of the risk assessment: (1) estimates of emission rates, (2) exposure assessment, and (3) toxicity assessment. The major uncertainties and the effects on the risk and hazard estimates are presented in Table 4-19.

4.2.2 Sensitivity Analysis on the Time Period of Combustion

A sensitivity analysis was performed to evaluate the effect of changes in the time period of combustion on total risk for all emission sources at TOCDF and CAMDS. The sensitivity analysis was conducted using (1) U.S. EPA-recommended exposure parameters and algorithms for characterizing risk, and (2) source-specific emission rates and air dispersion modeling results. The risk values described below were determined only as part of the sensitivity analysis and do not represent actual potential risk impacts associated with operations at DCD.

Risk estimates were determined using IRAP-h View. The sensitivity analysis was performed on a risk assessment project developed using air dispersion modeling and emission rates from the sulfur mustard trial burn data set evaluated in the risk assessment. An exposure scenario location was selected by utilizing IRAP-h View to identify an area of maximum deposition. To evaluate all potential exposure pathways, the default exposure pathways for the subsistence farmer (rancher) adult, including the fish ingestion exposure pathway, were selected. This approach ensured that the effect of the time period of combustion on all exposure pathways was evaluated. Default exposure scenario-specific exposure values (for example, ingestion rates and exposure duration) were used. Risk was then evaluated for operating periods of 1, 10, 20, 30, and 40 years. Forty years was set as the maximum time period of combustion to evaluate because it corresponds to the exposure duration for the subsistence rancher adult scenario. Sensitivities associated with the time period of combustion greater than 40 years were not evaluated since the facility is only expected to operate approximately 10 years.

The results indicate that the effects of the time period of combustion on total risk for the emission sources at TOCDF and CAMDS are insignificant. Varying the time period of combustion between 1 and 40 years had little effect on total risk (that is, less than one order of magnitude difference in results). These results suggest that the U.S. EPA methods used to estimate exposure and the conservative site-specific assumptions used to estimate COPC emissions overestimate the risks and hazards.

Little effect on risks and hazards were also measured at the source-specific level. The maximum change in risk was identified for the CAMDS HVAC, which showed slightly less than twice the risk with a 40-year period of combustion than with a 1-year period of combustion. Tables 4-20 and 4-21 list the results of the sensitivity analysis for cancer risk and non-carcinogenic hazard, respectively. The percent change was calculated as the percent change in risk between the 1-year period of combustion and the 40-year period of combustion (percent increase relative to 1-year time period of combustion).

TABLE 4-19 MAJOR UNCERTAINTIES IN TOCDF HEALTH RISK ASSESSMENT			
Major Element of the Risk Assessment	**Effect on Cumulative Risk and Hazard Estimates**		
	Underestimate	**Overestimate**	**Unknown**
Emission Rate Estimates			
Evaluation of non-detected COPCs at detection limits		•	
Lack of source-specific trial burn data and the use of surrogate emissions data			•
Lack of emission rate data on speciated metals			•
Exposure Assessment			
Use of U.S. EPA-recommended "default" fate and transport parameter values		•	
Evaluated exposure based on maximum air concentrations		•	
Use of U.S. EPA recommended "default" exposure parameters (for example, ingestion rates)		•	
General uncertainties and limitations associated with air dispersion modeling (for example, variability and representativeness of air modeling input parameters and meteorological data)			•
Use of limited site-specific watershed and water body input parameters			•
Lack of fate and transport parameters for many compounds	•		
Toxicity Assessment			
Evaluate toxicity based on extrapolated values			•
General uncertainties associated with toxicity values			•
Lack of toxicity values for many compounds			•

Notes:

COPC Compound of potential concern
TOCDF Tooele Chemical Agent Disposal Facility
U.S. EPA Environmental Protection Agency

The relatively small change in risk over varying durations of combustion is probably the result of the influence of factors on the algorithms used in the risk assessment (for example, site-specific parameters, COPC characteristics, and emission rates). In addition, significant changes in the calculated values caused by certain COPCs may be masked by other factors that influence risk. For example, some chemicals will exhibit an exponential loss in concentration from year to year, which would offset an increase in deposition of a chemical from facility emissions, as a result of certain fate and transport characteristics. However, the exact identity of the factors that contribute to the results at this facility is unclear.

4.3 EVALUATION OF SIGNIFICANCE OF COPCs THAT EXCEED DSHW REPORTING LEVELS AND U.S. EPA TARGET LEVELS

Section 4.1 lists the detected and non-detected COPCs that presented risk or hazard to one or more exposure scenarios. The procedures used to estimate risk posed by emissions from the treatment of agent at TOCDF and CAMDS are based on conservative or protective assumptions to ensure that no COPC that might cause adverse health effects is overlooked. The effects of these assumptions on the risk analysis are discussed below.

4.3.1 Uncertainties Associated with Emission Rates

As discussed in Section 2.3, it was necessary to extrapolate data from one facility to another to calculate emission rates for some scenarios. Additionally, not all of the COPCs identified during the COPC selection process were quantitatively evaluated during the risk assessment. Finally, several COPCs that have not been detected in samples of stack gas resulted in risk and hazard values that exceeded reporting or target levels based solely on their analytical detection limits. Therefore, various impacts on the uncertainties were introduced into the risk assessment as a result of the emission rates that were evaluated. The uncertainty evaluation included (1) an evaluation of the use of extrapolated emission rates; (2) the use of total organic emissions data to represent COPCs that were not evaluated; and (3) an evaluation of the likely presence of the non-detected COPCs in the waste feed and stack gas emissions. The final evaluation was completed by reviewing data on waste feed, chemical reaction kinetics, and other available information on the formation of PICs during the incineration process. This evaluation focused on the emission rates of phthalate esters, PAHs, EMS, and mercury.

TABLE 4-20
EFFECT OF THE TIME PERIOD OF COMBUSTION ON CANCER RISK

Source	Time Period of Combustion (years)					Percent Change
	1	10	20	30	40	
CAMDS HVAC	2.19E-12	2.66E-12	3.19E-12	3.71-12	4.23E-12	93
CAMDS DFS	3.52E-05	3.68E-05	3.85E-05	4.01E-05	4.15E-05	18
CAMDS MPF	2.02E-05	2.09E-05	2.18E-05	2.26E-05	2.34E-05	16
TOCDF BRA	6.53E-08	6.63E-08	6.74E-08	6.85E-08	6.94E-08	6
TOCDF DFS	1.02E-05	1.05E-05	1.09E-05	1.12E-05	1.15E-05	13
TOCDF LIC 1	1.60E-06	1.75E-06	1.90E-06	2.04E-06	2.13E-06	33
TOCDF MPF	3.19E-06	3.29E-06	3.41E-06	3.53E-06	3.63E-06	14
TOCDF HVAC	3.06E-10	3.36E-10	3.69E-10	4.02E-10	4.36E-10	42
TOCDF LIC 2	2.17E-06	2.32E-06	2.48E-06	2.61E-06	2.71E-06	25
Total Risk	**7.26E-05**	**7.56E-05**	**7.90E-05**	**8.22E-05**	**8.49E-05**	**17**

Notes:

BRA Brine reduction area
CAMDS Chemical Agent Munitions Disposal System
DFS Deactivation furnace system
HVAC Heating, ventilation, and air conditioning system
LIC Liquid incinerator
MPF Metal parts furnace
TOCDF Tooele Chemical Agent Disposal Facility

4.3.1.1 Extrapolated Emission Rates

Data from trial tests burns at JACADS, TOCDF, and CAMDS were reviewed to select an appropriate method for extrapolating emission rate data from one facility to another for scenarios where trial burn test data are not available. After the available trial burn test data had been reviewed, it was determined that extrapolating the emission rate data based on both (1) the ratio of actual to permitted agent feed rates, and (2) the ratio of actual to estimated stack gas flow rates, were the most reasonable techniques. Three different types of quality control checks completed to validate the extrapolation process indicated that extrapolated emission rates underestimated empirical stack-specific data by an order of magnitude in some cases and overestimated actual stack-specific data by as much as three to five orders of magnitude in other cases. Little difference was noted between the extrapolated values calculated using either feed and flow rate scaling factors. Based on these results, the overall impact of the extrapolation process overestimates the emission rates of COPCs used to complete the risk assessment and, therefore, overestimates risk.

TABLE 4-21
THE EFFECT OF TIME PERIOD OF COMBUSTION ON HAZARD

Source	Time Period of Combustion (years)					Percent Change
	1	10	20	30	40	
CAMDS HVAC	7.51E-06	7.51E-06	7.51E-06	7.51E-06	7.51E-06	0
CAMDS DFS	1.60E-01	1.80E-01	2.02E-01	2.23E-01	2.43E-01	52
CAMDS MPF	7.16E+01	7.18E+01	7.19E+01	7.21E+01	7.22E+01	1
TOCDF BRA	1.15E+02	1.29E+02	1.43E+02	1.57E+02	1.71E+02	49
TOCDF DFS	2.16E+01	2.16E+01	2.16E+01	2.16E+01	2.16E+01	0
TOCDF LIC1	8.33E-01	8.43E-01	8.54E-01	8.64E-01	8.75E-01	5
TOCDF MPF	8.71E+00	8.88E+00	9.07E+00	9.25E+00	9.42E+00	8
TOCDF HVAC	6.27E-04	6.27E-04	6.27E-04	6.27E-04	6.27E-04	0
TOCDF LIC2	8.33E-01	8.43E-01	8.54E-01	8.64E-01	8.75E-01	5
Total Hazard	**2.19E+02**	**2.33E+02**	**2.48E+02**	**2.62E+02**	**2.76E+02**	**26**

Notes:

BRA	Brine reduction area
CAMDS	Chemical Agent Munitions Disposal System
DFS	Deactivation furnace system
HVAC	Heating, ventilation, and air conditioning system
LIC	Liquid incinerator
MPF	Metal parts furnace
TOCDF	Tooele Chemical Agent Disposal Facility

4.3.1.2 Total Organic Emission Rates

The uncertainty associated with the omission of various organic compounds can be quantified by evaluating the mass of the total organic emissions (TOE) as compared with the mass of the 171 speciated organic COPCs that were used to complete the quantitative risk assessment. Data for TOE mass emission rates are collected during a trial burn test to measure the percentage (mass basis) of the total organic emissions that are quantified using various stack gas sampling and analytical methods that quantitatively identify individual speciated compounds. This ratio of total to speciated mass is known as a "modifier," because it can be used to adjust the emission rate of speciated COPCs to account for the organic mass in the stack gas emissions representing the individual organic compounds that have not been identified.

The values for the TOE modifiers that were calculated for TOCDF and CAMDS range between 0.6 and 7.3. These low TOE modifying values are primarily the result of the conservative approach (outlined in the protocol) for identifying and quantifying COPC emission rates at their detection limit. That is, only a handful of COPCs were detected during any one trial burn test; the sum of these detected emission rates would be very small compared with the TOE mass, resulting in very high TOE modifiers. However, the sum of the high number of values at the detection limit (and the handful of detected values) is near to, and in some cases exceeds, the measured emission rate of total organics by assuming that the entire target list of COPCs are being emitted at some detection limit value.

TOE modifiers were also calculated using only the sum of the emission rates that were evaluated quantitatively in the risk assessment (detected and non-detected) to assess the impact of the TOE modifier. The values for the TOE modifiers that were calculated ranged between 0.8 and 10.5. The consistency of the modifying factors (0.6 compared with 0.8 and 7.3 compared to 10.5) indicates that the mass of the COPCs evaluated quantitatively represent a large portion of the total organic emissions. Again, the sum of the emission rates for the COPCs evaluated quantitatively is near to, and in some cases exceeds, the measured emission rate of total organics.

Both sets of values indicate that (1) the use of the modifying factors as part of the quantitative risk assessment would have resulted in slightly higher, but overall negligible, differences in the organic emission rates calculated, and (2) the emission rates for speciated organic compounds used to complete the risk assessment represent the majority of the organic mass in the stack gas emissions. The uncertainty associated with non-quantified organics indicates a slight (less than one order of magnitude) underestimation of risk and hazard due to organic compounds.

4.3.1.3 Phthalate Esters

Emission rates for phthalate esters in the stack gas, including DNOP, contributed to an HI that exceeded the DSHW reporting level of 0.025 for several exposure scenarios. However, (1) many of the emission rates for phthalates are based on analytical detection limits (that is, the compound was not present above the detection limit) from previous trial burns at JACADS, CAMDS, and TOCDF; and (2) DNOP was detected during only one run of the CAMDS DFS VX trial burn test. Emission rates for phthalates above the analytical detection limits could also be a result of the ubiquitous presence of these compounds in the environment. The existing data on emissions rates of phthalates in the stack gas, on waste feed materials that contain phthalates, and the chemical reaction kinetics of phthalates were evaluated to evaluate the probability that phthalates might be present in the stack gas.

First, the rate of detected and non-detected phthalate emission rates was compared. This comparison showed no discernable trend between the various furnaces or agent campaigns, indicating that emission rates for phthalates measured above the analytical detection limit were not anomalous analytical data.

Second, waste feed materials that may contain phthalates were analyzed. This analysis showed that phthalates are components of the waste feed for both the MPF and DFS systems, but that phthalates are not likely components of the LIC systems. In the DFS, M55 rockets contain 19.3 pounds of M28 propellant, which is 2.6 percent dimethylphthalate (DMP). Based on the DFS propellant limits for TOCDF, this amount equates to a DMP feed rate of between 16.5 pounds (for GB) and 19 pounds (for VX). In addition to its use as a plasticizer in solid rocket propellants, DMP is used as a plasticizer for nitrocellulose and cellulose acetate, resins, and rubber that are components of waste feed for the MPF. DMP can also be found in lacquers, coating agents, safety glass, and molding powders (Sax and Lewis 1987).

Other phthalates may also be present in the feed to both the MPF and DFS. These compounds are widely used plasticizers and include:

- Diethyl phthalate, used as a plasticizer in solid rocket propellants, as a solvent for nitrocellulose and cellulose acetate, and as a wetting agent

- Di-n-butyl phthalate, used as a plasticizer in solid rocket propellants, as a plasticizer in nitrocellulose lacquers, elastomers, and explosives; in printing inks, as a resin solvent, in paper coatings, and in adhesives

- Butylbenzylphthalate, used as a plasticizer for various resins

- Bis(2-ethylhexyl)phthalate, used as a plasticizer for many resins and elastomers

Furthermore, one phthalate is often substituted for another in a phthalate product, because in most cases the intent is to achieve a specific physical result (such as viscosity at various temperatures), rather than a particular chemical composition. Commercial phthalates can easily contain a percent or more of impurities: for example, bis(2-ethylhexyl)phthalate is a routine contaminant of DNOP, and vice versa.

Finally, the chemical reaction kinetics of phthalates were analyzed. Phthalates and their predecessors are readily combusted compounds, as indicated by their flash points of 150 to 225° C; however, there is no apparent mechanism for combustion of other chemical compounds to create phthalates as PICs (U.S. EPA 1998).

Therefore, although the excess risk posed by emission rates of phthalates in the stack gas cannot be discounted based on the evaluation of these factors, the emission rates of concern for phthalates are largely based on (1) analytical detection limits, and (2) extrapolated emission rates (see Section 4.3.1.1).

4.3.1.4 Polycyclic Aromatic Hydrocarbons

Emission rates for PAHs in the stack gas, including dibenz(a,h)anthracene, benzo(a)pyrene and indeno(1,2,3-cd)pyrene, yielded a cancer risk for several exposure scenarios in excess of the DSHW reporting level of 1E-06. However, the emission rates for these compounds are based on analytical detection limits reported during previous trial and test burns at JACADS, CAMDS, and TOCDF. The existing data on emissions rates for PAHs in stack gas, waste feed materials that contain PAHs, and the chemical reaction kinetics of PAHs were evaluated to assess the likelihood that PAHs might be present in the stack gas at or just below the analytical detection limit.

First, the rate of detected and non-detected PAH emission rates was compared. This comparison showed no discernable trend between the various furnaces or agent campaigns, especially for the two PAHs that contributed to the excess risk.

Second, PAHs in the waste feed were analyzed. Although PAHs are not known components of the munitions, the MPF will be used to treat agent-contaminated dunnage and other waste materials during closure (for example, motors, bearings, and hydraulic hoses). Any materials in the waste feed contaminated with petroleum-based greases, oils, or lubricants may contain PAHs.

Finally, the chemical reaction kinetics of PAHs were evaluated. PAHs are readily formed in combustion units by either (1) dechlorination of chlorinated aromatic hydrocarbons present in the waste feed or emissions stream (such as dioxins), or (2) the reaction of simple aromatic compounds (benzene or toluene) present in the waste feed or stack gas (U.S. EPA 1998). PAHs are well known as the principal organic components of emissions from all combustion sources. Based on the toxicity and combustion chemistry of PAHs, the absence of these compounds from stack emissions should always be confirmed via stack gas testing (U.S. EPA 1998).

4.3.1.5 Ethyl Methanesulfonate

Emission rates for EMS in the stack gas resulted in an HI value in excess of the DSHW reporting level of 0.025. However, this compound has never been detected above the analytical detection limit during previous trial and test burns at JACADS, CAMDS, and TOCDF. The existing data on the emission rate of EMS in the stack gas, information on waste feed, and the chemical reaction kinetics of EMS formation were evaluated to asses the likelihood that EMS might be present in the stack gas at or just below the analytical detection limit.

As noted above, EMS has never been detected in stack gas samples. EMS is also not a component of any of the waste feed materials. Therefore, the only possible source of EMS in the stack gas would be as a PIC. Because all of the requisite components for EMS formation (thio groups, ethyl radicals, and methyl radicals) are expected to be present in the combustion system, it is possible—but unlikely—that EMS could be formed as a PIC. It is unlikely to be formed as a PIC because the same components required for formation of EMS would be expected to preferentially form other compounds that require less input of energy. Additionally, EMS is highly soluble in water. Based on the design of the pollution abatement systems at TOCDF and CAMDS, it is expected that EMS generated in the combustion chambers would be absorbed into the scrubbing solutions in the quench tower, venturi scrubber, and packed-bed scrubber systems.

Therefore, there is no reason to believe that EMS is present in the stack gas at concentrations at or just below the detection limits reported.

4.3.1.6 Mercury

Emission rates for mercury in the stack gas resulted in HI values for the adult and child recreationist scenarios and the fisher adult and child scenarios that exceed the U.S. EPA target level of 0.25. The existing data on the emission rate of mercury in the stack gas were evaluated to evaluate the source of the risk posed by mercury from various sources at TOCDF and CAMDS. This evaluation indicated that the TOCDF BRA is the largest single source of mercury—a source that is currently not in, and is not expected to return to, operation. In addition, the data for the BRA at TOCDF were collected during a failed compliance test, when mercury was not detected.

The TOCDF BRA accounts for about 93 percent of the total mass emission rate of mercury from all sources at TOCDF and CAMDS. Excluding the contribution of the TOCDF BRA would reduce the total mercury emission rate from 3.87E-02 grams per second (g/s) to 2.69E-03 g/s. Of this total, 80 percent is caused by emissions from TOCDF, and 20 percent is a result of emissions from CAMDS (non-time weighted).

Therefore, the calculated risk posed by mercury is based on a substantial overestimation of the emission rate of mercury currently permitted or projected for future operations. A new compliance test would be required to return the TOCDF BRA to operation.

4.3.2 Uncertainties Associated with COPC Fate and Transport Modeling

COPCs that present risk or hazard were evaluated using U.S. EPA-recommended values for fate and transport parameters. The recommended values may overestimate risk and hazard. The following sections (1) describe available information about the fate and transport of COPCs that present risk or hazard, and (2) evaluate the effect on risk estimates based on procedures recommended by U.S. EPA.

4.3.2.1 Risk from Chromium

Chromium (modeled as hexavalent chromium) presented risk that exceeds the DSHW reporting level for the on-site worker based on all COPCs. This evaluation conservatively assumed that chromium was emitted entirely in the hexavalent form. The hexavalent form of chromium is the most toxic valence state for this element and has been shown to be a human carcinogen through inhalation exposure. Conversely, trivalent chromium has not been shown to be carcinogenic in either humans or laboratory animals (U.S. EPA 1998). The current risk analysis did not account for the speciation of total chromium into hexavalent and trivalent forms. Therefore, impacts associated with exposures to chromium modeled as the hexavalent species may have been overestimated because the modeling of chromium fate and transport in the air and other environmental media did not account for the proportion of chromium present in the trivalent form.

U.S. EPA (1998) indicates that chromium emitted from a combustion unit is unlikely to be in the hexavalent form, and that the trivalent form most commonly exists in environmental media. Hexavalent chromium readily transforms to the trivalent form through interaction with elements in air, water, and soil. Chromium is present in air predominantly in particulate form and is deposited on land and water via wet and dry deposition. When it is present in the atmosphere, hexavalent chromium is readily reduced to trivalent chromium at a significant rate by interaction with vanadium (V^{2+}, V^{3+}, and VO^{2+}), iron (Fe^{2+}), hydrogen sulfate (HSO^{-3}), and arsenic (As^{3+}) (Agency for Toxic Substances and Disease Registry [ATSDR] 1993). In water, hexavalent chromium eventually reduces to trivalent chromium when it interacts with organic matter. Organic matter in soil readily converts soluble chromate (hexavalent chromium) to insoluble chromium (III) oxide. Chromium is usually present in soil as insoluble oxide and is not very mobile in soil. Therefore, the assumption that exposure to chromium is only from the hexavalent form overestimates the potential for adverse effects to human health.

4.3.2.2 Hazard from Di-n-octylphthalate

The risk assessment indicated excess hazard for the subsistence rancher and child scenarios from DNOP in emissions from the DFS and MPF units at both TOCDF and CAMDS. The risk assessment used conservative U.S. EPA-recommended exposure parameters that do not account for all fate processes that could affect the concentration of DNOP in the environment. In particular, the fate and transport algorithms rely on the COPC octanol-water partitioning coefficient (log K_{ow}) value. U.S. EPA (1998) recommends a log K_{ow} value of 9.33 for DNOP. Like any chemical property, the log K_{ow} value depends on the estimation method used to measure the property (Lyman and others 1982), which explains variability of values reported in the literature. For example, Howard and others (1989) report a value of 5.11, while ATSDR (1997) reports a value of 5.22.

The exposure factors U.S. EPA recommends for DNOP also do not account for the degradation of the chemical in the environment. Studies indicate that DNOP may degrade significantly in soils and water (ATSDR 1997, 2000; National Library of Medicine 2001). In a model terrestrial-aquatic ecosystem, DNOP was rapidly biodegraded by inoculated organisms with a half-life of 5 days. Aerobic degradation half-lives range from 1 to 4 weeks in surface waters and from 2 weeks to 1 year in groundwater. Anaerobic biodegradation may also occur but is not expected to contribute significantly. Abiotic degradation may occur through chemical hydrolysis. The U.S. EPA-recommended log K_{ow} value of 9.33 that was used to assess exposure to DNOP is based on laboratory tests that do not account for breakdown processes. Comparison of the value recommended by U.S. EPA of 9.33 to values that are available in the literature indicates the U.S. EPA value is extremely conservative, resulting in the overestimation of DNOP concentrations. Therefore, the U.S. EPA method for estimating DNOP exposure may overestimate DNOP hazard.

4.3.2.3 Risk from Ethyl Methanesulfonate

EMS was not detected in stack gas emissions, so it was evaluated for each unit at its detection limit. The sum of the CAMDS DFS and MPF risks for emissions estimated during the treatment of sulfur mustard exceed the U.S. EPA target level of 1E-05 for the drinking water pathway for the subsistence rancher adult and child scenarios. However, U.S. EPA's exposure assessment algorithms do not consider the fate of EMS in the environment when exposure is estimated. The following information from the National Library of Medicine's Hazardous Substances Databank (2001) was evaluated to characterize the fate of EMS in the environment.

Procedures recommended by U.S. EPA do not account for the breakdown of EMS released to the atmosphere. The half-life of EMS vapor that reacts with photochemically generated hydroxyl radicals in the atmosphere has been estimated to be 30 days, based on a reaction rate constant of 5.27E-13 cubic centimeters per molecule-second at 25 ^{o}C and an average hydroxyl radical concentration of 5.0E+05 molecules per cubic centimeter. Reaction with photochemically generated hydroxyl radicals and wet deposition remove EMS from the atmosphere (National Library of Medicine 2001).

EMS is completely soluble in water and rapidly hydrolyzes when it is released to water. The half-life for chemical hydrolysis of EMS has been estimated to be 96 hours based on a measured reaction rate constant of 7.2E-03 liters per hour at 20 ^{o}C. A soil adsorption coefficient (K_{oc}) of 27 was estimated for EMS using a linear regression equation based on its log K_{ow}. This K_{oc} value combined with the complete solubility of EMS in water suggests that there is no significant adsorption of EMS to suspended solids and sediments in water.

EMS is expected to hydrolyze very quickly after it has been deposited to soil. Based on a vapor pressure of 0.328 millimeters of mercury (mm Hg) at 25 ^{o}C, EMS will volatilize rapidly from dry soil.

Therefore, it is probable that the procedures U.S. EPA recommends overestimate the concentration of EMS in drinking water from surface water sources.

4.3.2.4 Risk from Polycyclic Aromatic Hydrocarbons

Two PAHs pose risk for the subsistence rancher scenario that exceed the U.S. EPA target level of 1E-05: indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene. These risk estimates were based on non-detected concentrations in stack gas emissions from the MPF at CAMDS and the MPF at TOCDF.

The risk assessment also followed procedures, recommended by U.S. EPA, that assume that PAHs absorbed into the blood stream are not metabolized. However, information in the scientific literature on the toxicodynamics of PAHs indicates, as discussed below, that (1) PAHs are readily metabolized, and (2) concentrations of PAHs in the human diet differ from concentrations predicted by U.S. EPA-recommended procedures. Therefore, the risk estimates for the subsistence rancher scenario are based on overestimated exposures.

To account for the breakdown of PAHs, Hofelt and others (2001) recommend that a metabolism factor (MF) of 0.01 be applied when calculating concentrations of PAHs in the beef, pork, chicken, egg, or milk pathways in multipathway risk assessments for hazardous waste combustion facilities. PAHs are metabolized primarily by the cytochrome P450 gene family of enzymes, and also can undergo metabolism by a variety of other enzymes to form epoxides, diols, triols, tetrols, phenols, and quinines, as well as conjugation reactions to form glutathioine and sulfuric acid conjugates (Grover 1986 [as discussed in Hofelt and others 2001]). These pathways result in removal of the parent PAH compound, via villary or urinary excretion or via macromolecular binding of a highly reactive intermediate species, thereby limiting the biotransfer of PAHs through the food chain (Hofelt and others 2001).

Furthermore, a review of scientific literature conducted by Hofelt and others (2001) indicated trends for PAHs in the total human diet that differ from predictions incorporated into the U.S. EPA (1998) model. First, several studies presented in Phillips (1999) (as presented in Hofelt and others 2001) revealed that most of the PAH contributions in the total human diet come from cereals, oils, fats, fruits, and vegetables, while the contributions from meat, fish, milk, and beverages are minor. These ratios differ from PAH concentrations predicted by the U.S. EPA (1998) model, which predicts significantly higher levels in beef and milk than in any other food (Hofelt and others 2001). In addition, analysis of animals in Kuwait exposed to high levels of PAHs as a result of oil fires after the Gulf War showed that there was no significant uptake of carcinogenic PAHs into the food chain (Husain and others 1997 [as presented in Hofelt and others 2001]).

Based on absorption, distribution, metabolism, and excretion (ADME) studies for benzo(a)anthracene, Hofelt and others (2001) first developed a PAH-specific metabolism factor (MF) of 0.001. An uncertainty factor of 10 was applied to the MF to account for interspecies differences in chemical disposition. To confirm the results for benzo(a)anthracene, MFs were calculated for other PAHs where ADME data in published literature are adequate. Calculated MFs for the other PAHs agreed with the value calculated for benzo(a)anthracene.

4.3.2.5 Risk from Mercury

A high degree of uncertainty is associated with estimating health impacts from mercury compounds. These uncertainties are predominantly associated with the unique site-specific nature and complex fate and transport mechanisms involved with mercury modeling. The U.S. EPA (1998) guidance is being revised to reduce these potential uncertainties. Significant revisions include dry vapor deposition modeling using mercury-specific deposition velocities and changes to the application of mercury speciations in the fate and transport equations. Although these changes are anticipated in the revised guidance, final values have not been released. In light of the complex nature of mercury modeling, it is unclear how these changes will alter current risk estimates for emissions from TOCDF and CAMDS. A discussion of uncertainty associated with current risk estimates will be deferred until the revised guidance is released because the revisions are expected to more accurately represent the fate and transport of mercury and mercury compounds in the environment and reduce overall uncertainty associated with mercury modeling. When a quantitative evaluation has been completed using the revised mercury modeling methodologies, a detailed section on uncertainty, including a discussion that compares the revised risk estimates, will be incorporated into subsequent versions of the TOCDF health risk assessment report.

4.3.2.6 Risk from Sulfur Mustard

The risk analysis indicated excess risk associated with exposure to sulfur mustard. Exposure to sulfur mustard results in several acute health effects (U.S. Army Center for Health Promotion and Preventive Medicine 2001). The risk impacts from mustard may have been overestimated because U.S. EPA procedures for assessing exposure and evaluating toxicity do not consider several physical properties of this chemical. As discussed below, the bioaccumulation and bioconcentration factors used to estimate concentrations of sulfur mustard in food do not reflect its rapid hydrolysis when it is released to the environment. In addition, sulfur mustard is highly reactive and would not accumulate in the active form in tissue, as predicted based on its log K_{ow} value.

Sulfur mustard hydrolyzes rapidly in water (ATSDR 1992), primarily through reaction with surface waters versus moisture in the air. Because of its ease of hydrolysis, after it is dissolved, sulfur mustard is not transported through the soil by groundwater. Sulfur mustard is also unlikely to be transported through vascular plant systems because it would already have undergone hydrolysis in the process. It is unlikely that humans would be exposed to this compound through ingestion of water, cooking, bathing, or swimming because sulfur mustard readily hydrolyzes in water.

Sulfur mustard is also highly reactive, and when applied to human skin, quickly evaporates (ATSDR 1992). Sulfur mustard vaporizes readily, largely depending on weather conditions. Sulfur mustard vaporizes most quickly when temperature and humidity are high with the presence of strong winds. It vaporizes two to three times faster at 20 °C versus at 5 °C. Experiments on rabbits and guinea pigs showed that sulfur mustard quickly evaporates from the epidermis after 1 hour of exposure. Other studies have indicated that only 10 to 25 percent of the sulfur mustard was absorbed into guinea pig and rabbit tissues after 1 hour of exposure. Because it is reactive, sulfur mustard does not bioaccumulate. It changes chemical form after it enters the human body and is excreted from the body within a few weeks (ATSDR 1992). Because sulfur mustard is highly reactive and rapidly evaporates, the potential for exposure and bioconcentration is low. Since this low potential for exposure and bioconcentration was not considered in the risk analysis, an overestimation of risk is probable.

5.0 DSHW STRATEGY FOR TARGET LEVEL EXCEEDANCES

U.S. EPA target risk and hazard levels were exceeded for:

- Indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene for the subsistence rancher exposure scenario for all agent campaigns

- DNOP for the subsistence rancher exposure scenario for all agent campaigns, with the highest hazard quotient calculated for the VX campaign

- Mercury for the recreationist and subsistence rancher exposure scenarios for all agent campaigns

When the risk assessment target risk levels are exceeded, modifications to the operating permit or additional evaluation are appropriate. Based on the available information, DSHW has concluded that potential health impacts from emissions are negligible. Therefore, permit modifications are not warranted, but additional evaluation is appropriate.

As discussed in Sections 4.2 and 4.3, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, DNOP, and mercury may not be present in exposure media (for example, air or beef) or may be present at concentrations lower than are estimated for the risk assessment. The additional evaluation includes testing for these chemicals during future trial burn tests and analyzing additional environmental samples, such as soil from around DCD, to help assess whether these chemicals are being released at hazardous concentrations. Additional details that describe the evidence and rationale used as the basis to conclude that permit modifications are not warranted are discussed in the following paragraphs.

Indeno(1,2,3-cd)pyrene and Dibenz(a,h)anthracene. The majority of the hazards from indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene are attributable to the consumption of contaminated homegrown foods such as milk, beef, and pork. Currently, only the beef pathway is complete in the vicinity of DCD, but the calculated cancer risk for indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene without the milk and pork exposure pathway still exceeds 1E-05. The methods used to estimate the concentration of indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene in food do not account for breakdown in the environment or metabolism that would result in concentrations lower than are predicted.

Indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene have never been detected in stack gases at TOCDF, CAMDS, or JACADS. PAHs, like indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene, have been detected at other incinerators and are likely present at some trace concentration below the analytical detection limit. The presence of these PAHs in emissions is uncertain but future testing at both the TOCDF and CAMDS will evaluate the presence of indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene. In addition, indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene will be monitored in environmental samples collected from around DCD.

DNOP. The majority of hazard from DNOP was attributable to the consumption of contaminated homegrown foods such as milk, beef, and pork. The Centers for Disease Control and Prevention (CDC) reports that accumulation of DNOP is not expected to be of concern in terrestrial food pathways because DNOP is metabolized (ATSDR 1997). Currently, only the beef pathway is complete near DCD, but the calculated HQ for DNOP without the milk and pork exposure pathway still exceeds 0.25.

Although some phthalates are known to be present in chemical munitions, DNOP has not been identified as a constituent of chemical munitions. DNOP was detected once during the VX rocket test burn at the CAMDS DFS in one of four test runs. If this single detection were an artifact, the DNOP HQ would still exceed 0.25, assuming that DNOP is present in stack gas at the analytical detection limit. The presence of DNOP in stack gas emissions is uncertain, but future testing at both the TOCDF and CAMDS will evaluate the presence of DNOP. In addition, DNOP will be monitored in environmental samples to be collected from around DCD.

Mercury. The majority of risk for mercury is attributable to the consumption of fish contaminated with methyl mercury. The fisher was evaluated as a potential future pathway for Rush Lake and Rainbow Reservoir. The potential exposure to mercuric chloride in soil also was identified as an exposure pathway of concern. Although the exact source is unknown, mercury is known to be present in some of wastes processed at the TOCDF and CAMDS and has been detected in stack emissions.

In the HHRA, the TOCDF BRA accounts for about 93 percent of the mercury emissions from processing GB. The TOCDF BRA has operated only a short time for testing and may never be operated again; therefore, current mercury emissions from the BRA are zero. Mercury was not detected during the rejected compliance test for the TOCDF BRA that processed PAS brines generated during the GB campaign. The compliance test was not repeated, but a successful test is mandatory before the BRA can begin operating. If mercury emissions from the BRA continue to be zero, the HQ for mercury is below the target level.

As demonstrated during test burns, the effectiveness of the pollution abatement system is limited for removing mercury. Therefore, characterization of mercury in the waste feed is critical to evaluating the potential health impacts from mercury. The TOCDF is undertaking enhanced characterization of GB waste feed material for mercury and other metals. When wastes that contain high concentrations of mercury are encountered, most of the mercury has been removed before it is incinerated. These efforts are anticipated to continue during the VX and sulfur mustard campaigns. In addition, the mercury hazard is specific to methyl mercury that may accumulate in fish. Samples from the environment, including fish, will be monitored to verify that mercury levels remain acceptable.

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